Owner-managed SME responses to innovative energy data and management tools: an action research case study

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Declaration

I, David C M Kenington, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Abstract

SMEs use more than 13% of global energy, so they are an important target to help achieve UK Net Zero targets. However, SMEs manage energy poorly, and little is understood about how to influence them to improve energy management.

Responding to this challenge, from 2018-2020, the UK Government delivered an £8.8 million Non-Domestic Smart Energy Management Innovation Competition (NDSEMIC), which funded the development of innovative smart meter data-based energy management tools. This thesis presents an action research study exploring the question: How do owner-managed SMEs respond to the development and testing of new smart meter data-based energy management tools?

The study involved working with one of the Competition participants, a technology innovation business, to inform the design of the tools from which a prototype was developed. Subsequently, the tools were tested, and other applications for smart meter and related data were explored with three owner-managed SMEs, two small independent chains of coffee-shops and cycle-shops and a coffee roastery business.

The findings identify that SMEs respond entrepreneurially to developing and testing smart meter data-based tools. Entrepreneurial activities led to identifying new potential uses for the tools to those anticipated at the outset; identifying operational roles, such as managing quality, productivity and premises security.

Entrepreneurialism theory, developed in SME business management research includes heuristics called Causation, Effectuation and Absence of Strategy. These heuristics are used to help better understand SME decision-making

when responding to the development and testing of new energy management tools.

These heuristics are recommended as a helpful approach to better conceptualise how to influence SME decision-making to improve energy management.

Impact Statement

The thesis examines an area of increasing policy interest; how to engage the SME sector in energy management issues and inform effective policies to improve energy efficiency and productivity.

The thesis offers three contributions to the research community. Firstly, it brings together small business entrepreneurialism research and energy management research for the first time. Doing so reveals new opportunities for researchers to conceptualise how to inform SME energy management improvements. Secondly, it offers an in-situ analysis of a) how an entrepreneurial organisation responds when challenged with developing new energy management tools through a Government sponsored innovation Competition and b) how owner-managed SMEs respond to the prototype tools and smart meter data. Thirdly, the thesis contributes to understanding the role of Action Research within energy demand studies, learning from and through action to inform responses at the pace and scale needed to help avert the Climate Emergency.

The small business sector has been considerably neglected in energy research, despite its significant influence on energy demand. The findings are being presented at SME energy demand forums, including the Net Zero Business Engagement Policy Unit within the Department of Business, Energy and Industrial Strategy (BEIS). Findings from the study are also being used to engage with the Energy Saving Trust and the Climate Change Committee as a follow-up to recent research and influencing activities focused on SMEs (Energy Saving Trust, 2022).

One academic paper focused on the pilot study, which informed this thesis, has been published (Kenington et al., 2019). A further academic paper is currently

in development, co-authored with colleagues from Hildebrand Technology, who were the main action research participants involved in the study. It is anticipated that further publications will be produced once the thesis is complete.

The PhD represents a partnership with a technology and services business that innovates with smart meter and other data to design and develop new solutions to engage energy users (homes and small businesses) and improve energy and operational management. The partnership also involved working closely with Government as the project focused on Hildebrand's work to develop SME-focused energy management tools in response to an innovation competition commissioned by BEIS called the Non-Domestic Smart Energy Management Innovation Competition (NDSEMIC). This type of collaboration is crucial for increasing knowledge transfer between academia, industry and Government if significant improvements are to be achieved in SME energy demand. The research has been presented and discussed in detail with Hildebrand Technology as well as the sponsoring team within BEIS on several occasions during the project. Hildebrand continues to work at the forefront of innovating with smart meter and other data to leverage demand-side benefits from the smart meter roll-out in UK and also operate internationally. Hence, the research potentially has international reach.

Acknowledgements

I owe a huge debt of gratitude to my supervisors Kathryn Janda and Paul Ruyssevelt, who have provided me with such helpful support and expertise throughout the PhD. I am also profoundly grateful to Lai Fong Chiu, who offered enormous support to me in helping design and implement the Action Research elements of the study, particularly in the earlier years of the project.

I am equally indebted to my Action Research participants who worked with me and had a fundamental influence on the outcomes of the project. First, I particularly need to thank Jane Wilson and Joshua Cooper from Hildebrand. This PhD would not have been possible without their support; I am incredibly grateful for their time, effort, openness in collaboration in the Action Research and genuine interest in the project. I am also very grateful to the three owner-managed businesses who so openly gave me access to their premises and staff and gave up their time to actively contribute to this research.

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Finally, I need to thank my family for their support and encouragement they have provided. My wife for her support and encouragement, whenever I felt like giving up, and for my children who have no idea what a PhD is but know it takes an enormous amount of time and effort.

Publications arising from this thesis

Material which informed the research scope and objectives of this study, undertaken for the MRes study, which preceded this PhD, has been published in the peer-reviewed journal Energy Research and Social Sciences (Kenington et al., 2019).

I am actively working to develop a paper to submit to a peer-reviewed journal for publication with my co-authors Kathryn Janda, Paul Ruyssevelt and Jane Wilson.

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Glossary

Abbreviation	Term	Definition
Absence of Strategy	n/a	If a company has a product line or serves particular markets without realizing an intended strategy or developing an emergent strategy, a firm is described as being 'absent of strategy'. Absence of strategy is a phenomenon of interest in business management research, exploring entrepreneurial logics. It has been observed to exist in various companies, more commonly within SMEs. It can be explored as a phenomenon alongside other entrepreneurial logics including Causation and Effectuation (Inkpen and Choudhury, 1995, Hauser et al., 2020).
AI	Appreciative Inquiry	Appreciative Inquiry (AI) is an approach taken within Action Research (AR) which focuses on 'searching for the best in people, their organisations and the strengths-filled, opportunity-rich world around them'. It is not so much a shift in the methods and models of organizational change, but a fundamental shift in the overall perspective taken throughout the entire change process to 'see' the wholeness of the human system and to "inquire" into that system's strengths, possibilities, and successes' (Rothwell et al., 2016).

AMR	Advanced Meter Reading	An Advanced Meter Reading is similar to a smart meter, and has been used for non-domestic metering in a range of situations both prior to and since the start of the GB Smart Meter roll-out. An AMR is similar to a smart meter however it can only communicate from the customer to an energy supplier (or an intermediary of the supplier), whereas a smart meter has two-way communication between the energy supplier and the business customer.
AR	Action Research	Action Research, is research *in* action , as opposed to research *about* action (Reason and Bradbury, 2008). The central idea is that Action Research uses a scientific approach to study important social or organisational issues together with those who experience it (Reason and Bradbury, 2008).
BEES	Building Energy Efficiency Survey	The Building Energy Efficiency Survey was a large-scale UK Government sponsored survey to improve and update the evidence of how energy is used, and to provide an assessment of the abatement opportunities for all non-domestic premises across England and Wales. (Department for Business Energy and Industrial Strategy, 2015).
BEIS	Department of Business Energy and Industrial Strategy	UK Government department responsible for Business, Energy and Industrial Strategy.

CAD	Consumer Access Device	A device which, in the context of smart meters bridges smart metering data with consumer led value added services, such as an in-home display (IHD). An examples of the CAD used within the GlowPro project is shown in Figure 19.
Causation	n/a	Causation is a an entrepreneurial logic utilised by scholars exploring small business behaviour in the management literature focused on organisational strategy. Causation processes take 'effect' as a given, and focus on selecting whatever means are needed to create that effect. Causation is often contrasted with the logic of Effectuation, whereby Causation behaviours tend to be dominant in larger organisations and Effectuation smaller organisations (Sarasvathy, 2001a).
CCA	Climate Change Agreements	Climate change agreements are voluntary agreements made between UK industry and the Environment Agency to reduce energy use and carbon dioxide (CO2) emissions. In return, operators receive a discount on the Climate Change Levy (CCL), a tax added to electricity and fuel bills. The Environment Agency administers the CCA scheme on behalf of the whole of the UK.
CCL	Climate Change Levy	The Climate Change Levy (CCL) is a tax on energy delivered to non-domestic users in the United Kingdom. Non-domestic users pay the CCL if their business is in the following sectors: industrial, commercial, agricultural and public services. However, the CCL is not paid if the organisation uses small amounts of energy (less

		than 33kWh electricity and/or 145kWh gas a day), is a domestic users or is a charity engaged in non-commercial activities. Organisations which have a CCA receive a discount on the CCL.
CEO	Chief Executive Officer	The highest-ranking person in a company or other institution, ultimately responsible for taking managerial decisions.
COO	Chief Operating Officer	The chief operating officer (COO) is a senior executive tasked with overseeing the day-to-day administrative and operational functions of a business.
CPP	Critical Peak Pricing	Critical Peak Pricing (CPP) is an optional time-based rate with different electricity rates based on the time of day it's used.
DCC	Data Communications Company	The DCC is a monopoly company that operates under the Smart Meter Communications Licence, which is regulated by Ofgem. It is responsible for linking smart meters in homes and small businesses with energy suppliers, network operators and energy service companies.
DSM / DSR	Demand Side Management / Demand Side Response	Demand side management (DSM) or demand-side response (DSR), is the modification of consumer demand for energy through various methods such as financial incentives and behavioural change through education. Usually, the goal of demand side management is to encourage the consumer to use less energy during peak hours, or to move the time of energy

		use to off-peak times such as night-time and weekends.
Effectuation	n/a	Effectuation is a an entrepreneurial logic utilised by scholars exploring small business behaviour in the management literature focused on organisational strategy. Effectuation is an entrepreneurial logic which follows a dynamic and interactive process for the creation of new artifacts. Effectuation is often contrasted with the logic of Causation, whereby effectual behaviours tend to be more dominant in smaller organisations and causal ones in larger organisations (Sarasvathy et al., 2008).
ERDF	European Regional Development Fund	The European Regional Development Fund (ERDF) is one of the European Structural and Investment Funds allocated by the European Union. Its purpose is to transfer money from richer regions (not countries), and invest it in the infrastructure and services of underdeveloped regions. This will allow those regions to start attracting private sector investments, and create jobs on their own.
ESOS	Energy Savings Opportunity Scheme	The Energy Savings Opportunity Scheme (ESOS) is a mandatory energy assessment scheme, introduced by the UK government to make sure large enterprises in the UK are energy efficient. Under the scheme, large organisations are required to assess their energy usage every 4 years and to find new ways to save energy.

ETL	Energy Technology List	The Energy Technology List (ETL) is a government list of energy efficient plant and machinery. In order for a product to be listed, it must meet the ETL's robust energy saving criteria - typically set at the top 25% of products in the market. The ETL features products such as boilers, electric motors, air conditioning and refrigeration equipment.
GlowPro	Hildebrand's prototype energy management tool	GlowPro is the name of the smart meter data based prototype solution developed by Hildebrand as part of the UK Government Non-Domestic Smart Energy Management Innovation Competition. Its purpose was to use smart meter and other data to help improve energy management in small businesses. Its design and development is one of the focuses of this thesis. A detailed overview of the GlowPro system is provided in section 3.3.3.
HMW	How Might We	How Might We' is a design thinking approach, which is commonly used in user experience design processes (Anderson, 2021).
HVAC	Heating, ventilation, and air conditioning	Heating, ventilation, and air conditioning (HVAC) is the use of various technologies to control the temperature, humidity, and purity of the air in an enclosed space. Its goal is to provide thermal comfort and acceptable indoor air quality.
IHD	In-home-display	In the context of smart meters; within the domestic part of the UK roll-out, a smart meter intervention will come with a small, plug-in portable device with a screen which shows your

		energy usage (electricity and/or gas) in terms of kWh or cost (£). An example of a typical IHD is shown in Figure 5.
LEP	Local Enterprise Partnership	Local enterprise partnerships (LEPs) are non-statutory bodies responsible for local economic development in England. They are business-led partnerships that bring together the private sector, local authorities and academic and voluntary institutions.
LS	Load Shifting	Load shifting is a strategy used within Demand Side Management (DSM) is a temporary reduction in electricity consumption that precedes an increase in production. This increase in production occurs when either grid demand or power prices are lower. Electricity storage facilities or generators can be utilized for this purpose. During load shifting overall electricity consumption stays the same; it's "shifted" to another period of time.
MOP	Middle Out Perspective	The Middle-Out Perspective (MOP) provides a lens to examine how actors positioned between government (top) and individuals (bottom) act to promote broader societal changes from the middle-out (rather than the top-down or bottom-up). The MOP has been used in recent years in the fields of energy, climate change, and development studies (Janda and Parag, 2013).
NABERS	National Australian Built Environment Rating System	NABERS is a national initiative managed by the NSW Government on behalf of the Federal, State and Territory governments of Australia. It

		provides a star rating for buildings based on operational performance, including energy data. The rating reflects a building's performance relative to its peers. Principally used for nondomestic buildings.
NDSEMIC	Non-Domestic Smart Energy Management Innovation Competition	The Non-Domestic Smart Energy Management Innovation Competition (NDSEMIC), was an £8.8M UK Government sponsored innovation competition, which funded the development of innovative smart meter data-based energy management tools between 2018 and 2020.
NVIVO	NVIVO	NVivo is a qualitative data analysis computer software package produced by QSR International. https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home
PC	Peak Clipping	Peak Clipping (PC) means the reduction of electricity system peak loads at specific periods. It embodies one of the classic forms of demand-side management (DSM).
POS	Point of Sale	The point of sale (POS) or point of purchase (POP) is the time and place where a retail transaction is completed. To calculate the amount owed by a customer, the merchant may use various devices such as weighing scales, barcode scanners, and cash registers or more advanced "POS cash registers", which are sometimes also called "POS systems". To make a payment, payment terminals, touch screens, and other hardware and software options are available.

PRP	Participatory Research Paradigm	The Participatory Research Paradigm (PRP) underpins Action Research (AR), which as an ontology makes an explicit link between object and subject, which is participative. A detailed explanation of the PRP is provided in section 3.2.2.
SBRI	The Small Business Research Initiative	The Small Business Research Initiative (SBRI) is a UK Government initiative, to enable research and development services to be acquired from private sector providers who develop, in competition, solutions for the public sector.
SC	Strategic Conservation	Strategic Conservation is a strategy used within Demand Side Management (DSM) to encourage consumers to reduce their energy consumption through behavioural changes.
SME	Small to Medium sized organisations	Small and medium-sized enterprises or small and medium-sized businesses are businesses whose personnel and revenue numbers fall below certain limits. In the UK, and SME is defined as any organisation that has fewer than 250 employees and a turnover of less than €50 million or a balance sheet total less than €43 million. Further, more detailed definitions are also provided for businesses within this definition, including medium (between 50 and 249 employees), small (between 10 and 49 employees) and micro organisations (less than 10 employees).

SMETS (including SMETS1 and SMETS2)	Smart Metering Equipment Technical Specifications	SMETS refers to the Smart Metering Equipment Technical Specifications, which define the functional requirements for smart metering equipment allowed to be part of the UK smart meter roll-out. SMETS1 was a standard applied during the Foundation Stage of the Smart Meter Programme, enabling suppliers to install meters facilitating early learning benefits. They were fitted a communications system to update suppliers with meter data at set intervals. However, if a consumer changed energy supplier, many of these types of meters stopped sending automatic readings. SMETS2 replaced the SMETS1 standard and is fully inter-operable, meaning that changing suppliers will not risk losing smart meter features.
SMIP	Smart Metering Implementation Programme	The UK Government is delivering the smart meter roll-out through the Smart Metering Implementation Programme (SMIP). The programme aims to roll-out approximately 53 million smart electricity and gas meters to domestic properties and non-domestic sites in Great Britain by 2025. This will impact approximately 30 million premises. The aim of the SMIP is to provide consumers with “real time” information on their energy consumption to help them control and manage their energy use, save money and reduce carbon emissions bring an end to estimated billing, make informed purchasing decisions reducing the barriers to switching between suppliers.

TOU	Time-of-use tariff	A tariff is a pricing plan for energy use. Time of use tariffs (TOU) use different prices to encourage consumers to use electricity at times when more is available cheaply.
TPI	Third-Party Intermediaries	A third-party intermediary (TPI) is an entity who helps connect two or more trading partners by acting as a conduit for goods or services between a supplier and consumer. A TPI may be an individual or an organization. In the context of energy supply in the UK, TPIs are organisations or individuals that give energy related advice, aimed at helping consumers to buy energy and/or manage their energy needs. TPIs include switching sites, energy brokers and any company that offers support with energy procurement.
USB	Universal Serial Bus	Universal Serial Bus (USB) is an industry standard that establishes specifications for cables, connectors and protocols for connection, communication and power supply (interfacing) between computers, peripherals and other computers.
Wi-Fi	n/a	Wi-Fi is the wireless technology used to connect computers, tablets, smartphones and other devices to the internet.

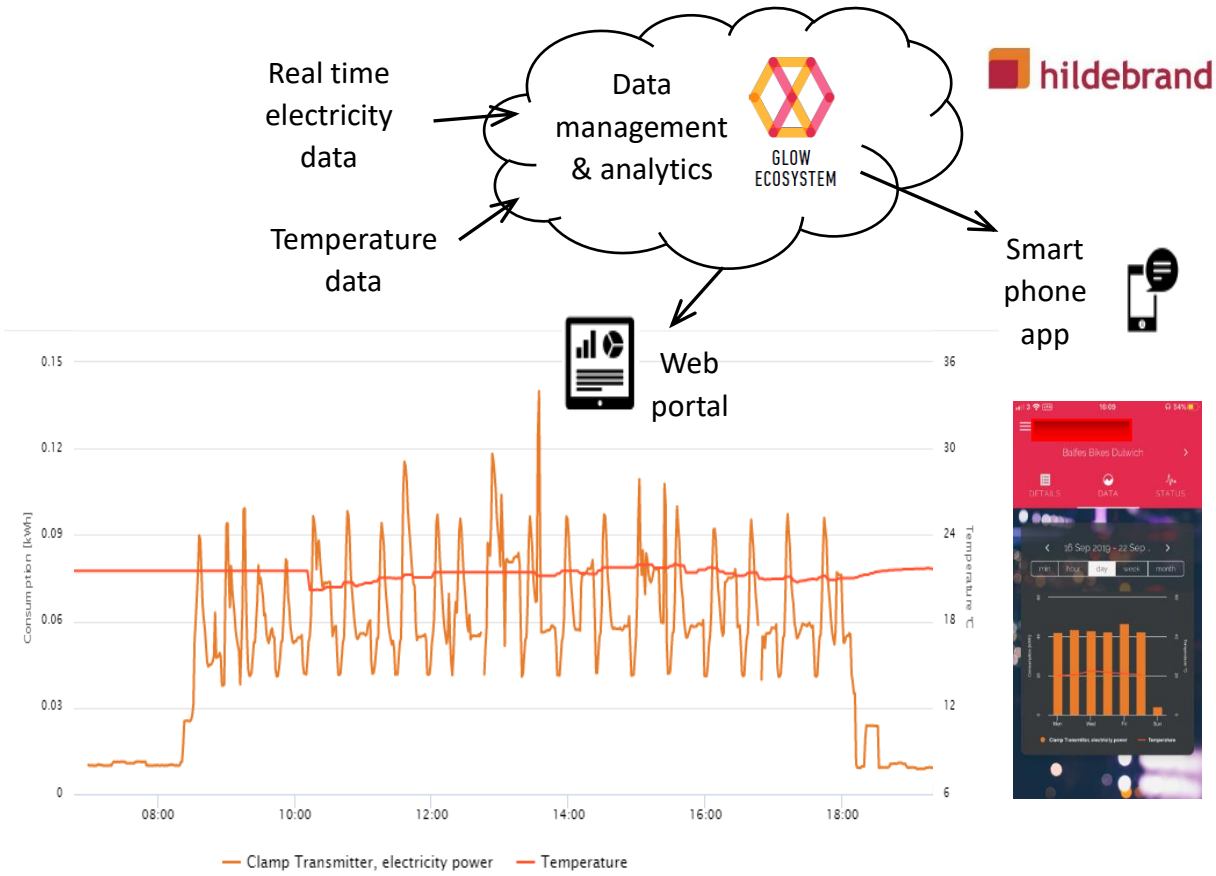
1 Introduction

1.1 Overview

This chapter sets the scene and presents relevant context within which this PhD situates itself.

This PhD explores how owner-managed small to medium sized enterprises (SMEs) respond to the development and testing of new smart meter data-based energy management tools. The study was done within the context of undertaking Action Research (AR), working with a UK Government funded innovation competition project, sponsored through the Non-Domestic Smart Energy Management Innovation Competition (NDSEMIC[1]). The project was led by a small, innovative technology firm called Hildebrand Technology[2], which in response to the Competition, developed a prototype smart meter data-based energy management tool called GlowPro to help improve energy management (Figure 1).

Figure 1: GlowPro prototype overview



[1] https://www.gov.uk/government/publications/non-domestic-smart-energy-management-innovation-competition-ndsemic-evaluation-findings
[2] https://www.hildebrand.co.uk/

This introduction chapter covers the following elements. First, I summarise SMEs and their energy use, including why they are 'hard to reach' and challenging to help improve energy management. This is followed by an overview of the recent UK policy context surrounding non-domestic (ND) energy use and the smart meter roll-out, including the NDSEMIC competition. I then introduce Hildebrand Technology and their role as one of the Competition participants, describing their project and its goals. This is followed by an overview of the study undertaken with them; first, working directly with Hildebrand to help inform the design of GlowPro and second, subsequently testing the prototype and exploring broader smart meter and other data-based innovations with three owner-managed SMEs. The following section introduces Action Research as the approach used for the study, and the main research question and research objectives are described. Finally, the structure and an overview of the main chapters, including the literature review, research methodology, findings, discussion and conclusions, are briefly outlined to help orient the reader.

1.2 Research context

Small to medium sized enterprises (SMEs) are responsible for 13% of global energy demand (IEA, 2015), and collectively they account for over half the energy demand from the industrial and commercial sectors in the UK (Department for Business Energy and Industrial Strategy, 2015). This makes them a sizeable target for emissions abatement to help meet Net Zero targets (Department for Business Energy and Industrial Strategy, 2021c).

The UK Government's definition of SMEs encompasses micro (less than ten employees and an annual turnover under €2 million), small (less than 50 employees and an annual turnover under €10 million) and medium-sized (less than 250 employees and an annual turnover under €50 million) businesses (Department for International Trade, 2020). In the UK, SMEs account for 60% of all employment and 52% of private sector turnover (Department for Business Energy and Industrial Strategy, 2018a).

Concrete evidence on SME energy-use and energy savings potential is lacking. However, the evidence there is indicates that, while cost-effective energy-efficiency potential may be drying up in other sectors (Sheil, 2020), there is still considerable potential within SMEs. A non-domestic UK Government sponsored building energy-efficiency survey made a conservative estimate that 18-25% of SME energy use could be abated cost-effectively and

that 37% of these savings would require zero capital investment (Department for Business Energy and Industrial Strategy, 2015).

Improving SME energy demand represents an exciting and difficult challenge. On the one hand, this is one of few sectors where there appears to be 'low hanging fruit' to help towards Net Zero targets. On the other, there are reasons why this is a complex problem to tackle. SMEs are a very heterogeneous sector comprising many very different kinds of organisations, each individually making a minimal contribution to overall energy demand. They are challenging to characterise, and little previous research has been done to better understand how they make energy-related decisions to inform more effective ways to improve energy management. It is a topic which requires further work to better understand how to realise energy savings potential achieved through improved energy management (Fawcett and Hampton, 2020).

As is described further in the literature review (Chapter 2), previous research exploring SME energy management has approached the problem in different ways, and there are many gaps and opportunities to further develop our understanding of the issue. One gap, which is explored within this thesis, is that SME energy management research has not connected extensively with broader SME business management research. Within this discipline, more research has explored how SMEs make decisions than in the field of energy management research. Such studies describe SME owner-managers[3] as entrepreneurs and have, over the past two decades, developed theories describing how they differ considerably from large businesses, particularly in how they make decisions. Entrepreneurialism heuristics such as Causation, Effectuation and Absence of Strategy are used to inform how SME owner-managers operate to maximise their chances of prospering, working within changeable and often perilous market contexts (Sarasvathy, 2001a, Inkpen and Choudhury, 1995). Such concepts have not been previously explored within energy management research and SMEs, which this study seeks to do.

[3] Precise statistics on the proportion of owner-managed businesses in the UK has proven difficult to find, however, business population statistics strongly suggest that the vast majority (>95%) are owner-managed (National Statistics, 2023).

1.3 Policy context

In the UK, like in many developed nations, non-domestic energy policies are set in ways that encompass all organisations or focus explicitly on large organisations. For example, key policies, including the Climate Change Levy (CCL), Climate Change Agreements (CCA) and the Energy Savings Opportunity Scheme (ESOS), focus on medium and large organisations, whilst there are almost none targeting small businesses. The UK's Clean Growth Strategy, which sets out policies to meet carbon budgets between 2023 and 2032, has very little focus on small businesses other than promising a consultation on how to improve the provision of efficiency advice and information (Department for Business Energy and Industrial Strategy, 2018b).

The UK has benefitted from EU policies, which have funded small-scale programmes of information, advice and financial incentives for SMEs through the European Regional Development Fund (ERDF). In England, through Local Enterprise Partnerships (LEPs), £125m has so far been awarded to projects under the 2014-20 programme, focused exclusively on assisting SMEs to implement energy efficient measures through grants, loans and the provision of free audits (Ministry of Housing Communities and Local Government and Department for Business Energy and Industrial Strategy, 2019). Various sources of advice to improve energy management have also been available from Energy Suppliers, Advice Organisations (e.g. Citizens Advice, Energy Saving Trust), Central or Local Government and others. However, other research by Citizens Advice showed that 40% of SMEs did not use any source of energy advice, and little is known about the take-up and/or efficacy of such interventions (Citizens Advice, 2017). Where interventions have occurred, there is little published evaluative evidence to help understand their success. Within what evidence there is, SMEs have been described as hard to reach, and even when they are targeted with interventions, they often get little traction. A review of UK business support interventions indicated a 'mixed level' of success (Blackburn, 2012), and others have called for changes in the provision of business advice services to make it more effective (Eadson, 2014).

Some of the more successful interventions to date have been regulatory ones, including energy-related products, building minimum standards, and associated labelling schemes (Ecodesign Directive - 2009/125/EC). Whilst these schemes are valuable in 'raising the floor' by removing energy inefficiency from the market, they apply to all businesses and do not

explicitly target SMEs. Governments are usually also reticent to include SMEs within regulatory interventions (especially ones which single them out) because they tend to be unpopular and are challenging to implement (Dahm, 2021).

Considering the issues above, the crux of the matter is two-sided; on the one hand, little is known about SMEs or how they operate, and on the other, there is little understanding of how to design and deliver interventions to improve SME energy management effectively. Both issues are causally intertwined, but covering both is difficult as it results in a broad scope, which traditional research approaches would struggle to do justice to, particularly within the over-arching context of an under-researched and heterogeneous sector like SMEs. However, in the context of the latest reports from the IPCC proposing that it is 'now or never' if we want to limit global warming to 1.5°C (Intergovernmental Panel on Climate Change, 2022), there are many reasons why further research is needed.

Innovative and more targeted research approaches are needed to inform how SMEs operate regarding energy while helping to inform specific interventions that can be implemented in the short term. Developing new, innovative smart meter data-based energy management tools is one area with promising potential to positively influence energy demand (Department for Business Energy and Industrial Strategy, 2017b). Finally, Action Research (AR) is an approach which can, in the right circumstances, provide insight across both these areas, as it can be used directly within the context of a developing intervention, which is the context within which this study was conducted.

1.4 Research design: Potential for Action Research

Action Research (AR), as the name suggests, is research *in* action , as opposed to research *about* action (Reason and Bradbury, 2008). The central idea is that AR uses a scientific approach to study important social or organisational issues together with those who experience them (Coughlan and Coghlan, 2002). Kurt Lewin first coined the term Action Research in the mid-1940s (Lewin, 1946) and described that *"If you want truly to understand something, try to change it"* which demonstrates the potential benefits of taking a participative approach.

Within the context of developing new interventions, Action Research enables researchers to work directly with those developing the intervention, or those influenced by it, to help inform its design and deployment.

1.5 Study context

This study focuses in the majority on the development and testing of smart meter data-based tools, undertaken whilst working as part of an innovation project funded by the Department of Business Energy and Industrial Strategy (BEIS) via a Small Business Research Initiative (SBRI) innovation Competition called the Non-Domestic Smart Energy Management Innovation Competition (NDSEMIC).

The UK smart meter roll-out is a major Government policy intervention to replace traditional gas and electricity meters with smart meters in the hope of making the energy system cheaper, cleaner and more efficient, helping to reduce emissions, and contributing to Net Zero goals (Department for Business Energy and Industrial Strategy, 2020b). The roll-out covers over two million non-domestic sites, most of which are occupied by small and microbusinesses[4] (Department for Business Energy and Industrial Strategy, 2019a).

NDSEMIC was an £8.8 million Innovation Competition designed to stimulate market-based innovation to develop energy management tools, which would help small businesses improve energy management. The Competition ran between 2018 and 2020 and aimed to maximise the potential for energy saving in three priority sectors; hospitality, retail and schools. The Competition developed and piloted seven energy management products and services to help smaller organisations improve energy management. For this PhD, I took the opportunity to work with one of the Competition projects, which focused on retail and hospitality businesses.

The study was split into two parts. First, I worked directly with one of the Competition participants, a smart data technology business called Hildebrand Technology Ltd. Hildebrand specialises in data analytics, behaviour change & energy management, and developing hardware and software for smart technology. They responded to the

[4] Supply licence conditions require energy suppliers to install smart metering systems (or in some circumstances, advanced meters) at premises whose average annual gas consumption is below 732 MWh per year and at all premises in electricity Profile Classes 1-4. Analysis by BEIS estimates this classification to include over two million non-domestic sites.

Competition with a proposal to develop new smart meter data-based energy management tools involving a system prototype called GlowPro, focused on supporting retail and hospitality businesses. During the Competition, I worked with Hildebrand and their consortium partners[5], utilising cycles of co-operative inquiry to inform the design and development of the tools.

In the second part, I took the opportunity to test the prototype tool with three owner-managed SMEs. I recruited a small chain of coffee-shops, a coffee roastery and a small chain of cycle-shops. I worked with their owners and premises managers over 18 months, utilising further cycles of co-operative inquiry to explore how they responded to the tool and broader potential uses for smart meter and other data to improve energy and operational management.

Working with Hildebrand and the businesses in this way helped uncover concepts within SME management research, particularly theories espousing entrepreneurialism in SMEs and how they can helpfully relate to and inform energy management research.

1.6 Research question and objectives

This PhD set out to answer the following primary research question – :

How do owner-managed SMEs respond to the development and testing of new smart meter data-based energy management tools?

Action Research (AR) studies set out dual objectives, supporting both context-level (practitioner) and meta-level (research) contributions (see section 3.2.6 for further details).

At the contextual-level of inquiry, the research question was supported by the following research objectives (RO).

- RO1: Informing the design and deployment of GlowPro energy management tools.
- RO2: Improving understanding of how energy management can be improved to reduce energy demand.

[5] Who included the following organisations: Love-Experience, Hopes, Gengame and Salford University.

- RO3: Informing understanding about what other benefits (e.g. co-benefits) smart meter data-based energy management tools may deliver or whether it might be better to consider energy management as a co-benefit of other, higher priority actions.

At the meta-level of inquiry, the research question was supported by this further research objective:

- RO4: Contributing to understanding about applying an Action Research approach in this context, learning about its strengths and weaknesses and developing recommendations for future work.

1.7 Thesis overview

This study is an AR project, which means it has several attributes that make it distinct from other research projects, and these are worth introducing upfront. Firstly, AR projects involve working *with* participants rather than *on* a particular subject area. As such, they are less well-defined at the outset and more flexible and changeable in delivery. Their outputs reflect the culmination of where one has gone on a journey and suggest where to go next, given what has been learned. As such, whilst the project had a research question and objectives, it took a broader than typical approach to answering them. AR projects tend to focus on areas, or cycles of 'inquiry', which involve stages, including problem diagnosis, planning action, taking action, followed by evaluation and critical reflection[6], which may inform further inquiry. The thesis is set out in this way and is structured into two parts (findings part 1 (chapter 4) and findings part 2 (chapter 5), with cycles of co-operative inquiry undertaken within them. It describes the analysis of findings along the way and where this culminated.

Part 1 of the findings (Chapter 4) involved working directly with Hildebrand to inform the design of the GlowPro prototype. I worked closely with their team and could experience and contribute to most of what goes into an innovative design project like this. The experience involved several surprises to me as a researcher focused on energy demand. The team took an entrepreneurial approach to the brief, which involved broadening the

[6] Critical reflection is a specific term used in AR and is explained in detail in section 3.2.3.

interpretation of the Competition's goals beyond energy management and into other aspects of business operations to design a tool they believed to be more beneficial for their target audience. On the one hand, this appeared to be at odds with the energy demand improvement goals of the NDSEMIC Competition, but on the other, the approach enabled them to develop helpful applications in an area where it is known that organisations pay little direct attention to energy management. Using an inductive analysis approach (Grounded Theory) helped make sense of this and led to the exploration of SME management research and entrepreneurialism. This analysis subsequently led to identifying entrepreneurialism theoretical heuristics called Causation, Effectuation and Absence of Strategy (Sarasvathy, 2001a, Inkpen and Choudhury, 1995, Hauser et al., 2020). These heuristics help understand SME strategic decision-making within different contexts (e.g. developing new products/services or maintaining existing ones) and thereby can help to inform how SMEs may respond to energy management or other interventions.

In part 2 of the findings (chapter 5) a semi-functional prototype of the GlowPro tool had been developed, so the focus changed to testing and exploring smart meter uses with owner-managed small businesses. This involved recruiting and working with three owner-managed SMEs over 18 months. This stage employed inductive and deductive analysis techniques and used Causation, Effectuation and Absence of Strategy heuristics to explore participatively with the businesses how they respond to external influences, such as new energy management tools.

This part of the research helped identify new ways to deploy smart meter data-based energy management interventions to improve operational and energy management. For example, integrating energy data into existing, widely used operational management systems (e.g. Point of Sale and Bookkeeping systems) and using the data to generate relevant energy metrics that are relatable to business goals. This also led to identifying new potential uses for the tools beyond those anticipated at the outset, identifying operational roles, such as managing quality and productivity.

1.8 Structure of the thesis

This thesis contains seven chapters. This introduction chapter is the first. It is followed by the Literature Review (chapter 2) and the Methodology (chapter 3). Two empirical findings

chapters follow this; chapter 4 focused on inquiry with Hildebrand, and chapter 5; focused on subsequent inquiry with the three owner-managed SMEs. Chapter 6 summarises the findings and provides discussion, and chapter 7 provides overall reflections and conclusions.

2 Literature review

2.1 Introduction and overview

This chapter describes the existing research landscape from which this study draws and in doing so, makes a case for why the study is of interest and how the literature bounds it. The literature review is structured in the following way.

The chapter starts with this section which briefly characterises the literature relevant to the study and the approach taken to review the literature. Section 2.2, builds on the narrative in the introduction describing SMEs and their energy use in more detail to show why they are a target for reducing energy demand and also why they are seen as very challenging to tackle.

Next, section 2.3 describes current knowledge about what SMEs do to manage energy, when and how, including how this relates to broader organisational activities to better understand opportunities to improve energy management. Where evidence exists, previous and existing interventions to improve energy management are described to help inform what is known about what has worked well and what has not.

Section 2.4 then reviews existing evidence relating to existing smart meter-data based energy management interventions and what is known about their potential to influence energy management, which helps inform the development of the energy management tools (GlowPro prototype).

Next, section 2.5 reviews literature describing opportunities and barriers to improving SME energy management to help further inform how one could intervene successfully with them. This section also discusses criticisms associated with such studies relating to their methods, the complex nature of SMEs, and the energy-related ecosystems they inhabit.

Next, section 2.6 looks more broadly at how researchers have characterised SMEs with a focus on improving energy management, thereby helping identify gaps this study can help fill. Specifically, this identifies gaps in understanding owner-managers and their behaviours and how this is crucial to understanding how to intervene effectively with energy management interventions.

Finally, section 2.7 explores SME organisational behaviour and theory, reflecting what is known from this body of literature and describing how it is relevant to exploring energy

management and related interventions. This is used to propose the use of an entrepreneurialism theoretical framework as a frame to explore the development and testing of smart meter data-based interventions, which I then go on to do within the subsequent sections of the thesis.

2.1.1 Literature review approach and search strategy

As the literature surrounding SMEs and energy management is small, the strategy employed to review the literature was more flexible and broader than other PhD literature reviews. Furthermore, whilst the research pertaining to the intersection of energy demand and SMEs is sparse, there is a very large body of research available on these subject areas individually. This was compounded by the nature of the terms used for searching within libraries, as unfortunately some of the terms, such as 'energy[7]' and 'small business[8]' are used in a variety of contexts which are much broader than the fields of research I was interested in. This meant that search strategies I utilised were often confounded by literature, which initially appeared that it might be relevant from the perspective of a search engine, but a review of the actual work would quickly show that it was not at all relevant. Whilst the search strategy utilised was not systematic, in the sense of how these are used within rapid evidence assessments or systematic reviews (Better Evaluation, 2022), I drew upon helpful elements of the methods to support the literature review. For example, firstly defining the scope of searches and initial search terms, followed by a rapid sense checking stage to review whether a study was likely to be relevant, in order to either select it for further in-depth review, or rejection. After this stage, I then assessed the quality of studies to decide whether to include these within the review or not. As there was likely to be evidence of relevance outside of academia I also utilised additional pragmatic strategies to explore literature from other sources such as grey literature. These included, searching the proceedings of conferences known to be relevant, including ACEEE[9], ECEEE[10] and the BEHAVE[11] conferences on energy and behaviour for articles including SMEs. I also reviewed

[7] Including more specific search terms, including energy management, energy demand management, energy demand.
[8] Including other similar search terms including small to medium-sized enterprises, SME, small organisations.
[9] The American Council for an Energy-Efficient Economy, holds a bi-annual summer study conference.
[10] The European Council for an Energy-Efficient Economy, which also holds a bi-annual summer study conference alongside a range of other seminars, workshops and subject specific conferences.
[11] European Conference on Behaviour and Energy Efficiency, which holds a conference on an approximate bi-annual basis.

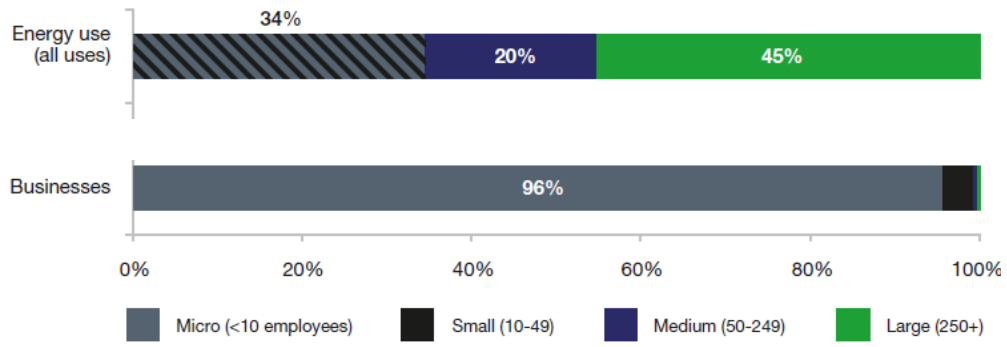
relevant Government publications, based on recent known UK and other developed nations non-domestic policy research and evaluations. In addition, within some of the highly relevant studies, identified through the search strategy, I reviewed literature they drew upon in depth to see if this identified further studies of relevance to review, utilising a snowball strategy (Lecy and Beatty, 2012). Given the use of these additional, and perhaps non-standard strategies, there is a risk that the review suffers from a greater degree of selection bias than others. However, it is felt that taking these approaches provided additional benefit to help seek out studies which would otherwise be hard to find.

The subsequent sections in this chapter describe the literature review fundings and how they have been used to inform the study.

2.2 SMEs and their energy use

This section builds on the introduction chapter exploring in more detail SME energy use to show why they are a target for reducing energy demand and why they are seen as being very challenging to target. There are estimated to be between one and two million SMEs, making up over 99% of all UK businesses. These are dominated by micro-businesses (96%)[12] , defined as those with less than 10 employees (Department for Business Energy and Industrial Strategy, 2018b). Over half (54%) of non-domestic energy use is used by SMEs, nearly two-thirds of which is from micro and small businesses, as shown in Figure 2.

Figure 2: Distribution of energy use, turnover and employment by business size (Department for Business Energy and Industrial Strategy, 2018b)



Source: Derived from Business population estimates, Non-Domestic National Energy Efficiency Data-Framework and Business Energy Efficiency Survey

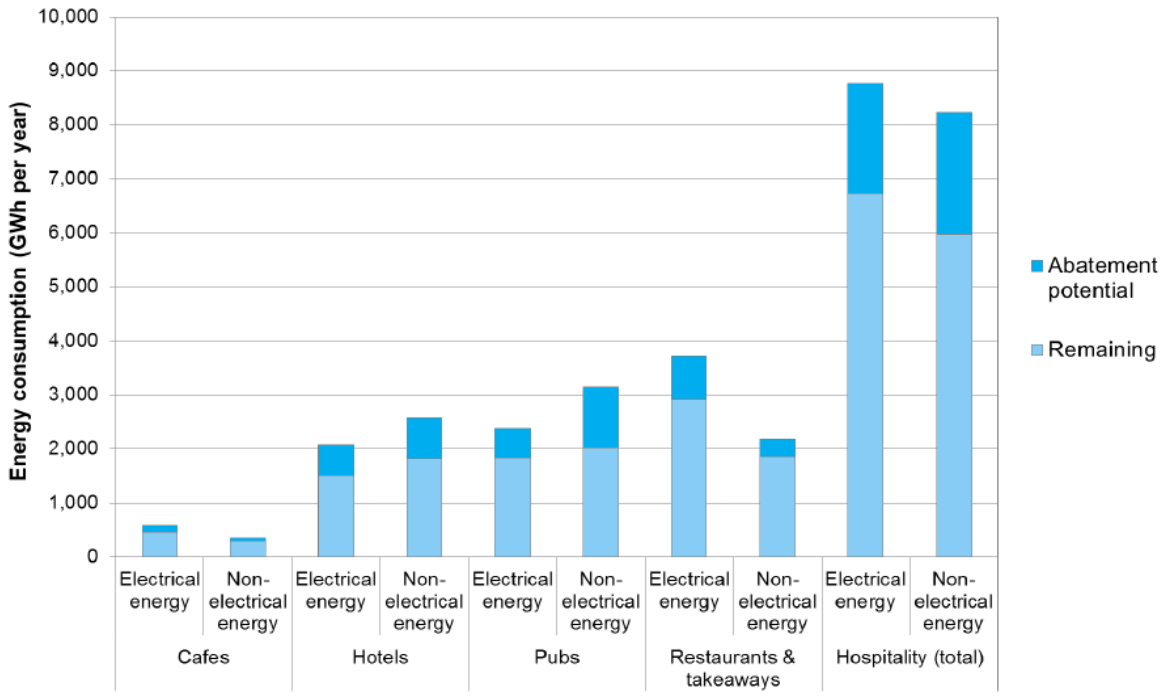
* The grey and black striped portion of the energy use bar (34%) aggregates micro and small businesses.

[12] Excluding home-based businesses (Department for Business Energy and Industrial Strategy, 2018b).

Despite their abundance and significant energy demand contribution, comparatively very little is known about the energy use characteristics of SMEs in the UK. What is known is that energy use is highly variable across SMEs, within and across specific non-domestic (ND) sub-sectors (Department for Business Energy and Industrial Strategy, 2015). The overall picture is complex and difficult to characterise. For example, previous research has found that organisations that are similar in size and activities can have very different energy demand profiles, and conversely, seemingly different organisations can have similar profiles (Lutzenhiser et al., 2002).

The UK Government's Building Energy Efficiency Survey (BEES) identified high levels of potential for energy demand abatement using existing and cost-effective efficiency measures (Department for Business Energy and Industrial Strategy, 2015). Figure 3 provides an example of this, showing abatement potential across the hospitality sector, which is relatively energy intensive. This sub-sector is also known to be dominated by SMEs and is estimated to have high levels of cost-effective technical abatement potential (25% of total energy use).

Figure 3 Abatement potential by energy type and hospitality sub-sector (Department for Business Energy and Industrial Strategy, 2015)



However, whilst there is high technical potential for energy efficiency, very little of this cost-effective potential is realised with meagre implementation rates observed in practice[13] (Department of Energy and Climate Change, 2014).

Policymakers and industry try to use approaches that target all or as many parts of a sector as possible to maximise impact (Jacques and Noël, 2020). This is difficult for heterogeneous groups like SMEs, which have been described as 'hard-to-reach' (Committee on Climate Change, 2016) and challenging to design and deliver policy for, to improve energy demand (Hampton and Fawcett, 2017).

There is a range of different ways in which SMEs have been characterised to try and tackle such challenges. These characterisations include size, for example; number of employees or turnover, as well as describing them by ND sub-sector. The ND sub-sector lens is helpful for energy demand social research studies, as they usually relate directly to how businesses define themselves and their activities, and activities tend to generally relate to their energy demand (Department for Business Energy and Industrial Strategy, 2015). However, this does not solve the heterogeneity issue, which has confounded researchers, as lessons from ND sub-sector-based research can be challenging to generalise more broadly.

The heterogeneity issue is compounded by SMEs individually representing a tiny proportion of overall energy demand. There are many SMEs compared to larger organisations, but most ND energy management research has occurred across large organisations. Large organisations, however, are known to be structured and behave very differently to SMEs, almost always employing staff whose primary responsibilities lie in managing energy use and costs, often within a broader facilities remit and manage energy closely as a significant cost-related issue. SMEs, by comparison, have very few dedicated energy management resources, which often comprise a small part of one person's role within their organisation. More action has been taken to research, understand and intervene to improve energy demand within large organisations, leaving SMEs lagging behind. As efforts to improve energy efficiency progress over time, this means that opportunity areas for efficiency and demand reductions may be drying up within larger organisations (Department for Business

[13] This research, commissioned by DECC reported an implementation rate of just 25% for opportunities with cost savings over £10,000 per annum amongst SMEs engaged in their research.

Energy and Industrial Strategy, 2015)[14]. In contrast, there is likely to be a greater abundance of cost-effective opportunities within SMEs, which needs to be accessed to meet Net Zero targets (Warren, 2017).

2.3 What do SMEs do to manage energy and how this relates to their activities

This section describes literature relating to what SMEs do to manage energy, when and how, including how this relates to broader organisational activities. This helps to understand potential opportunities to intervene to improve energy management. Knowledge about interventions to improve SME energy management and their relative success is described to help inform what has worked well, what has not and why.

Cooremans (2011) described that all organisations pay energy bills, but many do not actively 'manage' energy. Many SMEs do not have dedicated energy managers, and those who take responsibility for energy are known to have a limited understanding of their energy bills, let alone knowledge about how to improve their energy management (Payne, 2000, Coles et al., 2016). It has also been found that many fail to take up even the most cost-effective opportunities (Revell and Blackburn, 2007).

Many SMEs are owner-managed, which means responsibility for energy management usually lies with the owner(s) (Citizens Advice, 2017). What appears less well known are roles and whether (and if so, what) aspects of energy management are delegated to others. Previous research into SME energy management has found it to be much more informal and peripheral than in larger organisations (Hampton, 2018, Sa et al., 2015). The BEES survey estimated that 50% of total non-domestic building energy use lacked specialist energy management resources, and the most significant proportion of this comprised smaller businesses (Department for Business Energy and Industrial Strategy, 2015)[15]. Staffing is reported to be an acute problem among many SMEs, typically without an energy manager, who may not have the necessary information or skills to improve energy management

[14] Whilst it may be intuitive to assume this is correct, given knowledge about ND energy management, there is limited evidence available that accurately or consistently estimates energy demand abatement potential by organisation size. The BEES survey (Over-arching report, pp 92) estimated that the scope for energy efficiencies was greater for SMEs at 43% of consumption than in large organisations (36%).

[15] The usefulness of this data for understanding independent retailers is limited as the BEES survey reports only distinguish organisation sizes between large organisations and SMEs (<=250 employees). Independent retailers tend to be very small (<=9 staff, equivalent to a micro-business).

(Janda et al., 2014). Furthermore, many micro-businesses are believed to spend little time considering energy use explicitly, giving it little conscious thought except when bills arrive, or something goes wrong (Citizens Advice, 2017). Some owner-managers have been reported to feel reluctant and often unable to dedicate time to improve their knowledge of things they know little about (Ipsos MORI, 2013). Because of this and the nature of SME owner-managers (described further in section 2.7), professional activities can be intertwined with their personal lives, and energy management practices tend to have distinct similarities to domestic approaches (Citizens Advice, 2017).

Whether SMEs are owner-occupiers or leaseholders within their premises clearly affects the scope of influence of energy demand, and several literature sources (Cooremans, 2011, Economidou and Bertoldi, 2015) describe the issue of 'split incentives'[16]. Split incentives limit the potential for energy efficiency as tenants are not responsible for critical factors influencing energy demand (e.g. building structure and fabric), and landlords (who usually do not pay energy bills) are not motivated to improve efficiency. What is less well understood is the scope of the split incentive in the non-domestic sector (Bright and Dixie, 2014). This includes understanding responsibility for space heating/cooling equipment (HVAC) and/or property fabric (e.g. shop fronts, including doors and windows). There are some SMEs, particularly within retail and hospitality, where some or all occupants' energy bills are paid by a landlord or managing agent (e.g. shopping centres and some office spaces[17]), which further dis-incentivises occupiers from investing in energy efficiency (Axon et al., 2012).

There are conflicting findings within the literature concerning differences between those with higher or lower energy bills, with one report suggesting that those with higher energy costs pay more attention to energy management and have done more to reduce energy costs (Citizens Advice, 2017). In contrast, others found little evidence of differences in approach driven by magnitude of costs (Department for Business Energy and Industrial

[16] 'Split or misaligned incentives' refer to transactions where the benefits do not accrue to the person who pays for the transaction. In the context of building-related energy, it refers to the situation where the building owner pays for energy retrofits efficiency upgrades but cannot recover savings from reduced energy use that accrue to the tenant. (Economidou, 2014)

Strategy, 2017b). Finally, there are sector-specific reports describing how SMEs are significantly 'overspending' on energy bills (e.g. hospitality sector) and feel severely constrained in their ability to manage bills effectively (EEF, 2013).

There are many different energy management activities within the scope of this work, which utilises a broad definition. In keeping with other studies that have explored it previously, energy management includes paying bills, setting thermostats, setting timers, and switching on and off appliances (Hampton, 2018). These energy management activities are described further in the subsections below.

2.3.1 Energy billing and contract negotiations

When bills arrive or when supplier contracts are negotiated is one clear point at which SMEs explicitly consider their energy use and its costs. SMEs vary in their propensity to switch suppliers, with some switching on an annual or bi-annual basis and others doing so rarely, citing previous poor experiences of switching when questioned about switching reluctance (Ipsos MORI, 2017). When switching, organisations engaging with suppliers often use price comparison websites and other services such as Money Saving Expert (Ipsos MORI, 2013). Within the ND energy supply market, there is also a market of third-party intermediaries (TPIs) who target SMEs. These TPIs procure energy supply on behalf of their clients and charge commission for this, adding an additional layer of management, thereby limiting the extent to which SMEs know their suppliers and what rates they pay for energy (Ofgem and Citizens Advice, 2015).

2.3.2 Day-to-day operations

Day-to-day operational activities include opening up and shut down procedures at the start and end of the working day, use of lighting and controlling heating/cooling and other energy-using appliances. Whilst these activities directly influence energy use, they are intertwined with broader organisational activities, and their related energy use is not often explicitly considered at these points (Hampton, 2018). Existing research has shown that many small businesses believed that they felt they were doing '*as much as they can*' to manage behaviour efficiently; however other reports discuss that such beliefs may not play out effectively in practice, based on simplistic models of turning equipment down or off when not needed (Ipsos MORI, 2013). Other research has shown SME owner-managers feel

limited in their potential actions because most behaviours are perceived to be essential to their operations (Department for Business Energy and Industrial Strategy, 2017b).

2.3.3 Energy using equipment maintenance, repair and replacement

Maintenance, repair and replacement of energy-using equipment clearly influence energy demand. Energy-using equipment represents a substantial proportion of overall SME energy demand, particularly in more energy-intensive (energy use per m^2 floor area) sub-sectors like retail[18] and hospitality (Department for Business Energy and Industrial Strategy, 2015). Energy demand in this area is influenced by minimum energy performance standards (MEPS) (Department for Business Energy and Industrial Strategy, 2021a), but this is unlikely to be noticed by SMEs because they remove energy-inefficient equipment from being offered in the market (Massoud et al., 2010, Williamson et al., 2006). Energy labelling may play a role in product purchase decisions; however, there does not appear to be evidence regarding SMEs' awareness or take up of more efficient products due to labelling (Ecofys, 2014). There are various schemes in place to improve energy efficiency through equipment purchasing including the Energy Technologies List (ETL) and Enhanced Capital Allowances[19]. However, A UK technology sector representative has suggested that SMEs' awareness and take up of ETL is low (Tech UK, 2016). What is known to be important is that if the equipment is customer-facing, various performance and aesthetic considerations play an additional role in purchase decisions (Kenington et al., 2019). These could materially influence energy use, but their role is poorly understood. For example, research with high-street food retailers showed that it was challenging to suggest energy-efficiency-related additions to chilled counter displays (e.g. glass doors or lids), as these put a physical barrier between customers and products, which they believed would have adverse effects on customer spending (Kenington et al., 2019).

2.3.4 Premises refurbishment (including shop-fitting)

Premises refurbishment/retrofit is a significant energy efficiency opportunity, as the building fabric can be upgraded. The UK Government has developed policies to encourage

[18] Energy demand within retail is highly varied, and some sub-sectors, such as food and mixed retail are known to be very energy intensive.

[19] The ETL allows businesses to write off the entire cost of any product included on the list against taxable profits (Carbon Trust, 2107).

premises retrofit, although many affect only larger organisations or the public sector[20]. However, the extent to which SMEs are directly involved in fabric refurbishment activities is not well known. Shop-fitting, such as when a retailer moves into a (new or existing) premises, is likely to be a good opportunity for energy-efficiency interventions. However, little is known about how this works in practice, other than knowing there are businesses specialising in these activities, who tend to specify internal environments, and include energy-using products within their designs. Furthermore, little is known about whether, and if so how SME owner-managers get involved with these decisions (and whether energy is considered).

2.3.5 Interventions designed to improve energy management (including energy efficiency)

Despite the prevalence of high technical energy efficiency potential amongst retail and SMEs (section 2.2), there is evidence that take-up rates are poor (Revell and Blackburn, 2007, Citizens Advice, 2017).

Various sources of advice to improve energy management have been available, including Energy Suppliers, Advice Organisations (e.g. Citizens Advice, Energy Saving Trust), Central or Local Government and others. However, research by Citizens Advice showed that 40% of SMEs did not use any source of energy advice, and little is known about the take-up or efficacy of such interventions (Citizens Advice, 2017).

A range of audit, advice and interest-free loan support programmes are available for UK SMEs to support the take-up of measures[21]. However, there do not appear to be publicly-available evaluations of these schemes and little evidence regarding whether and if so, how these are taken up in small businesses is available. Anecdotal feedback from discussions with programme managers of such schemes suggests that targeting and getting take-up is a crucial challenge amongst smaller businesses. An evaluation of a similar Australian scheme found targeting of free audits to be challenging, and take-up of recommended actions was low (despite offers of grant and interest-free loans support). Reasons for poor uptake included lack of interest, insufficient resources, unsuitable recommendations, capital costs, and hassle associated with taking action (Hindson et al., 2012).

[20] Including the Energy Saving Opportunities Scheme (ESOS), Display Energy Certificates (DECs).

[21] Schemes include the Carbon Trust's Green Business Fund, Carbon Trust Wales Interest free loans and Resource Efficient Scotland SME loan fund.

2.3.6 Summary

In summary, this section has helped demonstrate understanding of what SMEs currently do to manage energy and how this relates to their organisational activities. It appears that there are limited times when energy is explicitly considered, such as when they negotiate and pay their bills. This is undertaken at a different time from when energy-related activities are occurring, which highlights a disconnect. Furthermore, there is little evidence available to know whether and, if so, how energy-use is considered when critical energy-related activities are undertaken such as shop-fitting and maintenance or replacement of energy-using equipment. These activities considerably influence energy use, which can be 'locked-in' for many years, but the evidence indicates that energy-use is given little consideration at these points. This is likely to be because this connection is hidden, due to activities of intermediaries (e.g. shop-fitters, suppliers) who have little interest in ongoing energy demand, and that energy is seen as a lower priority within other activities at these times. Smart meters have considerable potential to help here as they can make the relationship between operational activities and energy use more visible, thus enabling energy to be considered at these points. The following section explores smart meter data-based interventions and their potential for improving energy management.

2.4 Smart meter data-based interventions

This section describes existing smart meter-data based energy management interventions and what is known about their potential to influence energy management, which helps inform the development of the new smart meter data-based management tools, which is the focus of this study.

First, evidence on the impacts of smart meter based interventions is explored, followed by an exploration of theory and evidence of how improved energy demand outcomes are achieved.

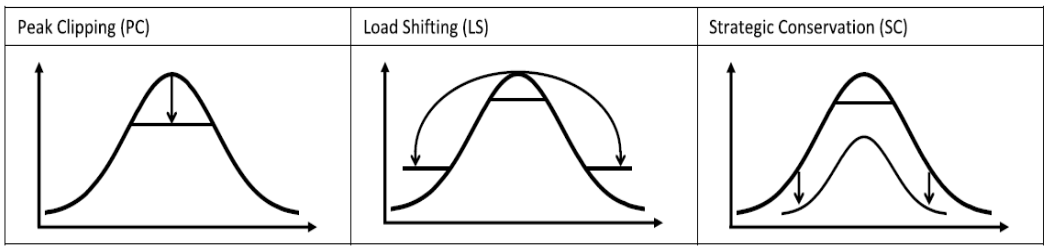
There is very little evidence in the literature exploring smart meter based interventions within small non-domestic sites[22] (Staddon et al., 2016). However, as there is evidence that many SMEs draw on domestic energy management activities for their businesses (see

[22] Particularly of the types of businesses within scope of the smart meter roll-out.

section 2.3.1 (Citizens Advice, 2017)), there is likely read across from these so I have broadened out this aspect of the review to include domestic interventions.

As described in the introduction, the roll-out of smart meters to domestic homes and small businesses is a significant Government supported intervention in the UK and many other countries, predicated based on their foreseen efficiency and cost-saving benefits. In the UK, they are assumed by Government to make a considerable contribution to achieving 2050 net zero targets (Department for Business Energy and Industrial Strategy, 2019b). Smart meters can provide consumers with energy use information and other signals, which holds the promise of translating energy from something which is 'abstract, invisible and untouchable' into something 'transparent, dynamic and controllable' (Fischer, 2008). Smart meters enable consumers by giving them information they previously did not have, which leads to lots of possible opportunities for demand-side management (DSM), which leads to energy savings, which is one of the main bases upon which Government justifies intervention. There are three types of DSM benefits, shown in Figure 4.

Figure 4: Demand response and shape of load curve obtained (Batalla-Bejerano et al., 2020)

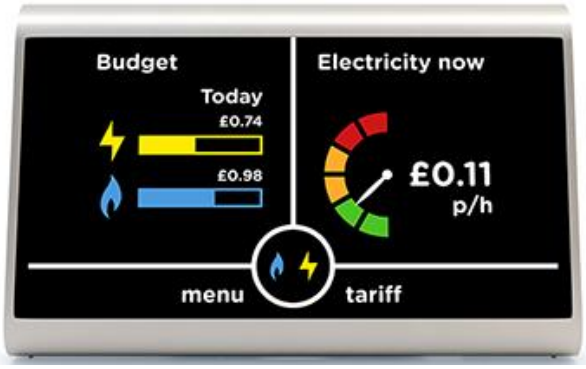


Peak clipping (PC) is a strategy where overall demand peaks are reduced. National electricity demand fluctuates throughout the day, normally peaking around in the morning and early evening and more costly generation technologies are needed, often with higher associated emissions to meet that demand. Load shifting (LS) acts similarly, although it is focused not on reduction, but on moving demand outside of the peak, for example, by moving the use of high energy-consuming appliances to other times (e.g. through the use of time delay settings). Finally, strategic conservation[23] (SC), is the most common strategy found in the literature, whereby strategies encourage consumers to reduce their

[23] Defined by Batalla-Bejerano as the execution of activities that reduce energy consumption (Batalla-Bejerano et al., 2020).

consumption through behaviour changes (Batalla-Bejerano et al., 2020). A range of interventions have been used to influence consumer demand responses, which, as described in the introduction, fall into two main categories: energy information feedback and price incentives. The most common interventions involve providing energy consumption and cost information, often through a web portal or a specific in-home or premises display (IHD), an example of which is shown in Figure 5.

Figure 5: Example of a common smart meter display showing electricity and gas consumption (Smart Energy GB[24])



In addition, further information to influence energy-saving can be used, such as identifying whether consumption is low, medium or high against a relevant comparator (e.g. the average household or premises) (Lossin et al., 2016) or providing details on the impact of that consumption on the environment or public health (Asensio and Delmas, 2015). Peak-clipping interventions have involved messages provided by an electronic device like that shown in Figure 5, but incorporating a warning system, for example, showing a 'red alert' on critical peak days or times, which may also include pricing signals either through time of use (TOU) or critical peak pricing (CPP) tariffs (Ivanov et al., 2013, Asensio and Delmas, 2016). Load-shifting interventions have used similar approaches but have focused on analyses of pricing effects using TOU tariffs as well as feedback information (Zhang et al., 2016).

A systematic review of smart meter data based energy demand interventions has shown that many of these studies (Batalla-Bejerano et al., 2020) delivered positive outcomes for peak clipping and load shifting. However, the scale of impacts varied considerably, both

[24] https://www.smartenergygb.org/en/about-smart-meters

within and across studies ranging from very small (e.g. <5%) to nearly 40% of demand either being reduced during the peak, or shifted outside of it.

Strategic conservation is the most common type of study found in the literature. Whilst the focus of these studies was on overall demand reduction, the types of interventions utilised were similar to those used for peak clipping and load shifting, albeit with a greater focus towards overall energy conservation. These studies enabled overall energy demand impacts to be calculated across complete periods (i.e. weeks or months). Batalla-Bejerano et al's systematic review (2020) also identified an extensive range in outcomes, from 2% (Quintal et al., 2013) to a 32% reduction (Petersen et al., 2007, Costanza et al., 2012). Another systematic review (Buchanan et al., 2018) also found a considerable variation in impacts (5-20%) across all types of studies and found that the more methodologically robust studies tended to report impacts closer towards the lower end of the scale. Within the literature, there are very few non-domestic SME-focused interventions; however, Spence et al. (2018) reported a 37% decrease in electricity use following an e-visualisation intervention (e-Genie tool) targeted at energy users within an office, which is discussed further below.

Overall, there are several reasons discussed in the literature as to why there is considerable variation in impacts across studies. These include technical and methodological differences, ranging from experimental designs to analytics, simulations and surveys. However, the main reason for the variations was because they are information-based interventions and are dependent on variable behavioural responses. Buchanan et al. (2015) raise questions about the efficacy of information and feedback, describing that many studies have not explored in detail the longevity of impacts and expressed concern that, in many cases, longevity was relatively short within those that did. Furthermore, questions have been raised about the efficacy of real-time displays provided, with one study; a large-scale trial involving 60,000 households showing that for those who were provided with only a real-time display (i.e. no additional advice or information), only one in four of them reported a statistically significant reduction in energy use (AECOM, 2011).

As described above, there is very little literature examining the impacts of smart meters on SMEs. In the UK, this is likely due to low numbers of smart meters[25] having been rolled out to small ND sites at the time of this research[26] and because suppliers are not obligated to share the data with customers (unlike for the domestic part of the roll-out, which requires free data access and IHDs (Department for Business Energy and Industrial Strategy, 2020c)).

In summary, review of the literature exploring the impacts of smart meters based energy interventions have identified that most interventions focused explicitly on energy feedback and also pricing. Whilst almost all studies report that energy savings are realised from the interventions, they vary, ranging from small to 30-40% reductions. Almost all impact studies have focused on domestic interventions and there is a considerable gap in evidence regarding small ND sites. As described further below, SMEs are a very different context where there are different actors (owner-managers, staff, contractors) involved with different interests and stakes in energy management, which means little is known about whether or how effective smart meter data-based interventions can be.

2.5 Opportunities and barriers to improving SME energy management

Looking more broadly than smart meter data-based interventions, studies have explored opportunities and challenges surrounding improving energy management in SMEs. This section explores this evidence to help further inform how one could consider how to intervene successfully with them.

Several studies have explored opportunities and barriers to improving SME energy efficiency. Within these studies, many barriers have been identified, as shown in Figure 6 and Figure 7. First, these include a lack of awareness and knowledge, including a lack of understanding of energy bills and strategies to reduce them. These have also been associated with a lack of interest or time, often exacerbated by a lack of resources (Revell and Blackburn, 2007, Trianni and Cagno, 2012). Second, legal and infrastructural barriers, such as split incentives tend to reduce the take-up of fabric-related opportunities, such as

[25] Specifically meters which meet the UK Government SMETS standards, the technical standards associated with the smart meter roll out.

[26] At the end of 2018, when this research commenced only 82,338 smart meters (SMETS compliant) meters had been installed in ND premises (by September 2022 this has increased to 324,224), as published by BEIS. https://www.gov.uk/government/collections/smart-meters-statistics

insulation (Economidou and Bertoldi, 2015). Third, economic and hidden costs[27] , as well as investment-related risks and return on investment challenges, are reported, which reduce the take-up of equipment and fabric-related measures (Fleiter et al., 2012). Finally, technology-related information and a range of other barriers have been identified (Department for Business Energy and Industrial Strategy, 2015). Trianni and Cagno (2012) undertook surveys with non-energy intensive SMEs exploring barriers to energy efficiency, reporting the barriers shown in Figure 6. Furthermore, more recent studies have explored barriers further, for example, Lunt et al (2014) developed a cognitive map exploring the interplay between barriers, shown in Figure 7.

Figure 6: Analysis of barriers to the adoption of energy efficiency interventions and experience in energy audits (Trianni and Cagno, 2012)

	Have you adopted EE interventions in the recent past (3 years)?		Have you conducted energy audits in the recent past (3 years)?		Av. score
	Yes	No	Yes	No	
Y1 – Lack of time or other priorities (comparing energy efficiency efforts with respect to production efforts)	2.37	2.63	2.10	2.58	2.53
Y2 – Access to capital (lack of capital - public and/or private - to be devoted to energy efficiency investments)	2.92	3.08	2.76	3.07	3.03
Y3 – Lack of internal technical skills	2.51	2.86	2.76	2.69	2.70
Y4 – Difficulty of gathering external technical skills	2.13	2.52	2.33	2.35	2.35
Y5 – Poor information for the energy efficiency decisions	2.49	3.00	2.62	2.80	2.77
Y6 – Lack of personnel awareness	2.14	2.34	2.05	2.29	2.25
Y7 – Lack of managerial awareness	1.90	2.11	1.86	2.06	2.03
Y8 – Other priorities for capital investments (low returns for energy efficiency investments)	2.47	2.71	2.43	2.65	2.61
Y9 – Scarce information regarding energy efficiency opportunities and winning solutions	2.62	3.05	2.57	2.90	2.85
Average score for the barriers	2.40	2.70	2.39	2.60	
DM – Difficulty in implementing management interventions	2.14	2.52	1.81	2.47	2.35
DT – Difficulty in implementing technical interventions	2.43	2.72	2.57	2.59	2.59

[27] For example, additional works (e.g. decorative work) required to ensure aesthetics of the premises are not compromised.

Figure 7: Cognitive map of organisational energy efficiency barriers (Lunt et al., 2014)

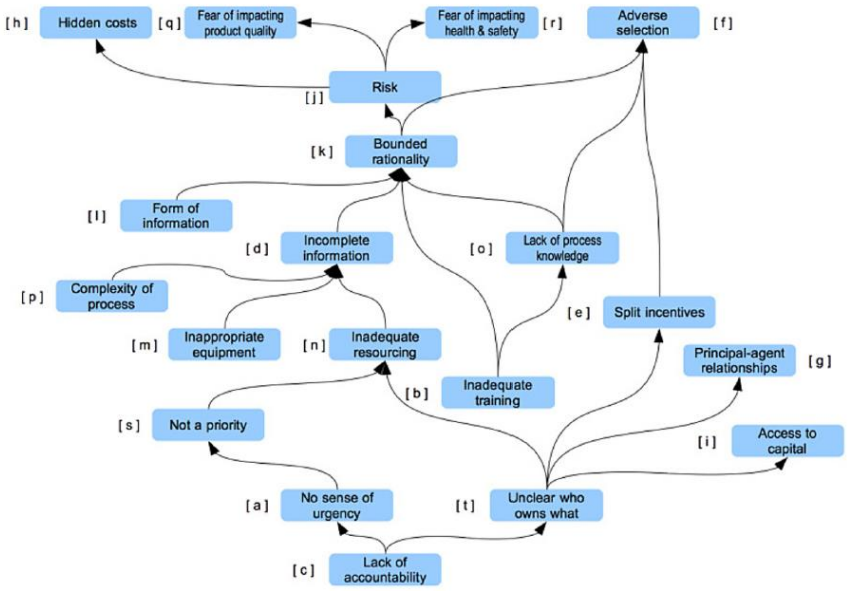


Figure 4.
Cognitive map of the barriers

The elicitation of barriers is no doubt helpful in trying to understand how to overcome them, and these studies have been influential in the design of policy interventions to support energy efficiency take up in SMEs (Hampton, 2018). However, a range of methodological criticisms has also been made about them. First, Hampton and Fawcett (Hampton and Fawcett, 2017) raise concerns concerning studies' over-reliance on surveys and interviews with business owners and managers who could be more likely to identify financial or external barriers as reasons for inaction, as opposed to identifying a lack of knowledge or other internal issues. Furthermore, the models of decision-making which underpin the literature that tend to assume that SMEs will act according to rational economic principles when barriers are removed (Revell, 2007, Revell and Blackburn, 2007) have been questioned. Hampton and Fawcett (Hampton and Fawcett, 2017) argue that this framing only gives a partial account of decision-making, which means that it is likely that the removal of barriers is unlikely to deliver the anticipated take up in energy efficiency measures. Finally, some studies have also challenged this empirically by showing that take-up rates of energy efficiency opportunities are meagre among SMEs compared to the identified technical potential. In particular, they pointed out that many opportunities did not require any capital outlay but were still not taken up (Revell and Blackburn, 2007, Department for Business Energy and Industrial Strategy, 2015). Responding to such

challenges, other work has been done to explore other ways to conceptualise SME energy management and how it can be influenced, which is the focus of the following subsection.

2.6 Characterising SMEs in the context of energy management

As described above, this section looks more broadly at different ways in which researchers have characterised SMEs with a focus on improving energy management. This section also addresses some of the many gaps in the SME energy management literature, and discusses new ways in which these gaps can be addressed. Specifically, this identifies gaps in understanding owner-managers and their organisational behaviours and activities.

Some researchers have investigated the characterisation of SMEs in different ways to help frame the issue in a way that aligns more closely with how organisations work in practice. Andrews and Johnson (2016), in their review of evidence on energy behaviours, used a conceptual framework of studying organisational behaviour around three levels of analysis. First, *individuals working within organisational settings,* considering personal influences on their behaviour (e.g. attitudes, beliefs, values). Second, the *characterisations of organisations themselves*, both formal and informal that influence the behaviour of individuals within them (for example organisation goals and expectations, structures and procedures, group norms etc.). Third, they also considered *institutional rules, structures and context within which the organisation acts* (e.g. markets, Government regulations, sectoral and professional 'norms'). This is a helpful framework as it considers different possible influences on energy management both internally (staff and management) and externally (outside influences), so I explore each of these levels of analysis below, first individually and then together, below.

Individuals within workplaces

There have been only a few studies exploring individuals within workplaces as change agents. This likely to be for two reasons; firstly, the scope of influence of individuals within workplaces is constrained by broader organisational decision making, and likely limited to daily behavioural activities (E.g. shutting off computers and lights). Secondly, there is almost always no direct benefit to employees for energy saving activities, as energy bills are paid by their employer.

Dixon et al. (2015) used Ajzens Theory of Planned behaviour framework (Ajzen, 1991) and found that attitudes, perceived control and descriptive norms appeared to be good predictors of energy conservation intentions and that a sense of community also had some effect. Other studies have explored the diffusion of energy conservation through social networks. Darley and Beniger (1981) found that, rather than individual attitudes, individuals' behaviour is deeply influenced by the norms and actions of those around them with whom they identify, the norms of their workgroup and its larger organisations, and also by their broader networks of professional peers. Another area of study has focused on exploring the influence of innovation champions, where either senior (top-down) or junior (bottom-up) staff act as champions in motivating behaviour change. Within these types of studies, it appears that context is critical in determining the effectiveness of interventions. For example, an intervention has a much greater chance of success if the champion is viewed positively and they are good at aligning their interventions within their corporate contexts (Lynne and Thomas, 2000). There are questions surrounding what might happen if such interventions are done in organisations where employees and employers do not have such good relationships, particularly as energy-saving benefits generally accrue to the company and not individual employees. Looking at the impacts of these studies, whilst some identified interventions with positive energy-saving outcomes, they appear to be small compared to overall energy use (<5%).

Organisations as a context

Studying organisations as a context has provided insights into a range of areas. First, studying organisation-led interventions on workplace energy conservation behaviour has shown that setting goals and targets between 'relatable' workplace teams can be successful, and can employ gaming strategies to beneficial effect (Siero et al., 1996, Simon et al., 2012). Secondly, several studies have explored organisational under-investment in energy efficiency measures. Despite favourable economic payback, they had poorer than anticipated take-up and identified reasons for this which closely align with the organisational barriers described above (Figure 6).

Institutional rules structures and context

This lens focuses on factors influencing energy behaviour in organisations, including the rules, norms, beliefs and logics embedded in organisations' broader institutional context. Andrews and Johnson (Andrews and Johnson, 2016) describe three isomorphic processes, coercive, mimetic and normative pressures and explore each of these in relation to energy behaviour.

First, coercive pressures mainly comprise formal market-wide influences such as regulations; for example, national energy efficiency standards for appliances and buildings. The effectiveness of this can be examined by looking at research and evaluations of these types of interventions; for example, EU Minimum Energy Performance Standards and Labelling, which has been described as having a transformative effect on appliance energy performance (Schleich et al., 2021, Regulatory Assistance Project, 2020). At the firm level, it has been asserted that national-level energy policies have a key role in inciting SMEs to take action to improve energy efficiency investment decisions making (Cooremans and Schonenberger, 2019), however as described above, such policies that directly target SMEs to do this are rare.

Second, mimetic pressures influence behaviour through pressures exerted by competitors and business peers. In energy behaviour, this can be seen through, for example, voluntary best-practice standards run by industry associations or Governments. The Australian NABERS energy performance star rating scheme was introduced in 1998 as a voluntary initiative[28] and was quickly adopted by the commercial property market, which promoted the rating scheme as a way of demonstrating the efficiency of commercial real estate. The scheme has been very successful, claiming to have reduced carbon intensity by 32 percent between 2009 and 2019 across the office sector (Arreza, 2020, Bannister, 2012, Mallaburn et al., 2021).

Finally, normative pressures include the 'norms' of business partners, customers and other stakeholders, which have also been shown to influence energy behaviour. For example, some lending institutions now include energy performance among screening standards when reviewing business loans (Equator Principles, 2020). Henriques and Sadorsky (Henriques and Sadorsky, 1996) found that organisations' environmental plans are

[28] Later becoming mandatory through Government regulation in 2010, owing to the success of the voluntary scheme.

influenced most by customer and shareholder pressures, as well as Government (i.e. regulatory) and local community pressures.

Looking across these three types of influences (coercive, mimetic and normative), it appears that many examples of studies have found high levels of influence and impact on energy behaviour. This contrasts with many studies focusing on individuals and organisations, where most studies have found more negligible impacts or those which have not delivered in comparison to identified energy efficiency potential. This suggests that intervening at this level may be more effective, which could be related to the greater influence these pressures have on core organisational strategies, however there is little in the literature that explores this in detail, particularly how this might influence SMEs. This is explored further in section 2.7.

Finally, in summary, looking across all of the lenses considered above, it is clear that all of them (individuals within organisations, institutional rules structures and external context) will have interrelationships in practice, and consideration of just one will negate opportunities presented by others. This reflects the complexities of SME structures and the ecosystems they work within, which all relate to energy. The following sub-section explores energy management across all three contexts.

2.6.1 Exploring energy management across individuals, organisations and external contexts

As described by DeCanio, organisations are not like individuals. Their behaviour is the outcome of the interplay of the motivations of the individuals comprising it, the rules and conventions governing their interaction, and the environment within which they operate (DeCanio, 1993).

While many studies have looked at one or more of the three elements described above, very few have sought to look across all of them, seeking to capture the range of acting influences and explore their interplay. Recognising this, Janda et al. (Janda et al., 2002) and Lutzenhiser et al. (Lutzenhiser et al., 2002) developed a heuristic framework called “3Cs” in order to better explain such phenomena by considering social and technical issues together within an organisational context. These include various relevant actors (e.g. occupants, organisations, landlords, agents, buildings, equipment) and relationships between people, energy and buildings. The framework describes that energy efficiency actions are

dependent on 3Cs – "Concern" (within organisations about energy efficiency relative to other goals), "Capacity" of organisations to act and "Conditions" – real-world conditions at their premises that are to be acted upon. Recognising the lack of nuance and interdependence of the factors in reality, Janda (Janda, 2014b) subsequently further developed the 3Cs framework to 4Cs, including a 'building communities' aspect (Fig. 1). This recognizes the units of analysis commonly used in business settings (either organisations or individuals) and therefore helps to accommodate the perspectives of building stakeholders at different levels; for example, occupants, building managers, organisation ownership and senior management. The 4Cs framework also points to "grey" areas above, below, and between individual employee and organisational levels that additionally influence work context and decision-making, for example, public acceptance, professional institutions and public policies (Bull and Janda, 2017).

Figure 8: 4Cs framework: concern, capacity, conditions within a community (Janda, 2014b).

		3Cs		
	Analytical level	**Concern** (factors that shape attention to energy)	**Conditions** (factors that shape where energy actions occur)	**Capacity** (factors that moderate abilities to take energy actions)
Building communities (grey area, neither organizational nor individual)	**Organization**	Legislative requirements, leases	Building retrofit opportunities, thermostat setpoints, standard operational hours, provision of space & equipment	Energy management structure; job titles & responsibilities; feedback & data availability; granularity of data
		Workstyles	Clothing choices, (e.g., "casual Fridays"), activities outside "normal" hours	Peer pressure & social practices; workgroup dynamics
	Individual	Attitudes, beliefs, habits, values	Use of task lights, computers, auxiliary heating/cooling devices; extra plug loads; operation of blinds/windows	Presence or absence of champions; expertise & understanding of systems; interest in and ability to act on feedback

The framework has been used to help describe the influences of each of these elements, and how they influence within the context of each other and has been described as a helpful step forward in undertaking research of organisations and energy efficiency. However, the framework has not been extensively tested empirically in order to better understand what the most influential aspects or levers that exist within it to most effectively influence energy behaviours are. In my research prior to undertaking this study, I tested the framework adapting the 4Cs framework for use in SMEs by narrowing the "community" dimension of stakeholder analysis (Kenington et al., 2019). The study explored energy efficiency in independent retail, and testing the framework in this context demonstrated the importance of commercial influences on energy services as an influencing factor, shaping 'concern'. For example, several seemingly obvious energy efficiency opportunities (identified by an energy

audit) were quickly ruled out because they did not 'fit' with business needs or did not take account of underlying organisational contexts. Conversely, other opportunities, which may not have seemed obvious to an energy expert, were explored with interest, particularly where there was associated commercial benefit (e.g. new refrigerated display cabinets, which would have improved shop displays seen by customers doing their shopping). This study again indicates that exploring organisational strategy and its influences further may be helpful to understand effective levers better to improve energy behaviour within organisations.

2.6.2 Exploring energy behaviours using sense-making and practice theory

Hampton and Fawcett (Hampton, 2018) utilised an alternative approach, looking in-depth at SME energy management using two conceptual frameworks; practice theory and sense-making. Sensemaking research attends to how meanings, identities and knowledge are constructed through processes such as retrospection, performative enactments or the telling of stories (Weick et al., 2005).

Practice theory and sensemaking focus on organisations as they happen, and in so doing, they encourage reflexivity and flexibility from researchers (Spaargaren et al., 2016). This may have been possible to undertake in this project as the fieldwork they undertook was part of a long-term project providing expert energy advice over time[29], where they could engage with a range of staff on multiple occasions over a year or more. What appears very helpful from this work is that sensemaking engenders a focus on a specific event, or series of events that may help to explain in detail key elements of energy management activities ordered such that they take account of the different actors involved, their stakes and influences to make clear sense of them in order to inform action. Utilising practice theory can elicit similar insights, but viewed from the perspective of looking at energy behaviours as practices, and in so doing, enables consideration of the important aspect of how energy behaviours relate both in the physical spaces where they occur as well as within the social context of the people involved. This is beneficial because much observed energy behaviour (particularly within SMEs) appears habitual and implicit, making it hard for researchers to decipher and, when viewed through previously described techno-economic lenses, make little 'rational' sense. However, approaches employing practice theory and sensemaking also

[29] As part of an EU funded project, providing subsidised energy advice to SMEs.

have limitations. First, they encourage very detailed exploration on specific practices, which can limit the ability to draw generalisable conclusions, both because SMEs undertake a broad range of complex activities and because SMEs themselves are so heterogeneous, insights which are relevant to one business may not be to another. Second, in focusing on observed behaviours or practices themselves and their influences, you may fail to take sufficient account of the broader fundamental reasons underlying the behaviours (i.e. you may be investigating the symptoms of something and not the cause).

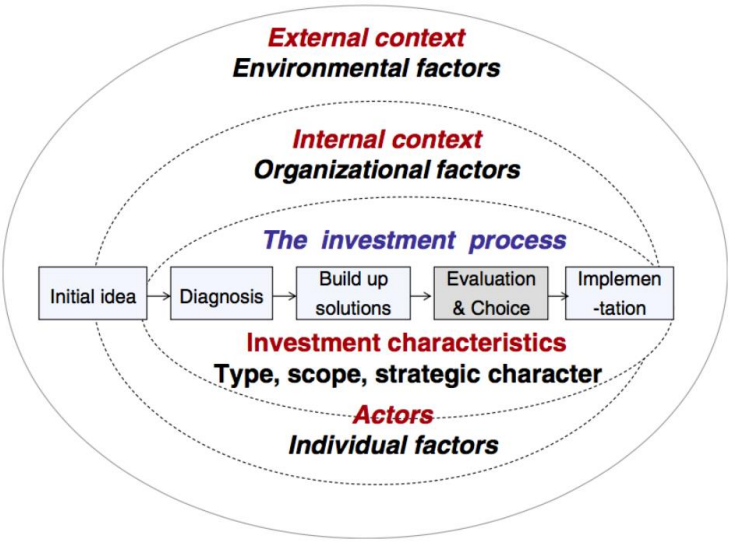
2.6.3 The role of salience and organisational strategy

Stepping back from the range of ways in which energy management has been studied, a common theme across all of them is that they tend to focus on exploring energy-use as an explicit phenomenon in of itself. This translates into the research methodologies employed; for example, by exploring with organisation representatives energy and its influences in some depth and from various perspectives. Whilst this makes sense within the realm of energy demand research, because of the nature of the problems being explored, arguably, this makes much less sense when stepping into the shoes of the organisations being researched. As described by many of the drivers and barriers studies described above, most SMEs rarely consider energy as an explicit issue, and when they do, it tends to be of limited concern and as just an operational expense, as opposed to something deeply considered, for example as part of organisational strategies (noting that very recent energy price rises will likely have changed this perspective to some extent).

Mallaburn (2016) discusses this issue in his report on non-domestic energy efficiency policy for the Committee on Climate Change (CCC). He discusses the importance of understanding how energy fits with the organisation's broader investment decision-making processes and what internal and external factors render it sufficiently salient to influence decisions and precipitate action. And further, he discusses that without this, we cannot hope to understand the multiple barriers to investment in energy-efficient technologies within organisations in the non-domestic sector, including knowledge, financing, and culture (Yeatts et al., 2017).

In the context of energy-efficiency investment decision-making processes, usually undertaken by large organisations, Cooremans described how salience works as a nuanced process with a beginning, middle and an end (Cooremans, 2012).

Figure 9: A model of energy efficiency decision-making (Cooremans, 2012)



Mallaburn goes on to describe 'salience drivers', both external (e.g. reputational drivers) and internal (e.g. relevance of energy-use) to the organisation, which should be taken into account when designing policy interventions, going on to recommend salience as a conceptual model to inform energy efficiency policy design.

Given the issues described in this literature review, taking such an approach makes sense to increase the take up of energy-efficiency measures. However, this is explored within the context of both large organisations (who usually have dedicated energy management staff) and energy-efficiency investment decision-making; for example, when investing in retrofit activities or purchasing new equipment. It is difficult to see how this model of decision-making would translate to SMEs, where energy is given much less active consideration, and also smart meters, where the 'intervention' is mainly information (i.e. smart meter data), as opposed to an efficiency measure in-of-itself.

Nonetheless, exploring organisations, their drivers and strategies, particularly amongst SMEs is a clear gap in energy behaviour research, which would benefit from further exploration. It also seems like this could be an opportune area in the ND sector, as unlike other areas like the domestic sector, most businesses do have clear organisational purposes and goals that they are trying to achieve; for example, making profits or achieving growth. Within SMEs, these goals may not always be explicitly clear, for example in the form of an organisational strategy, and it may not be sensible to always assume that they are always

focused on growth or profit maximisation[30]. However, this area is likely to have at least some elements of consistency between organisations, unlike other aspects of the ND sector, which, as described above, is highly heterogeneous.

Notwithstanding the above, there are reasons why there is a lack of research in this area. First, organisational strategy can be challenging to research as it can involve commercial sensitivities, particularly in the private sector. Second, as energy-demand (prior to recent energy price rises) is often not a high priority as an explicit concern, exploring how it relates to strategy is likely to take some exploration to develop an appropriate methodology and collect data and insights from suitable sources. Within large organisations, strategy and energy is usually managed by different, often entirely separate teams, and the former are usually very senior and, therefore, difficult to target. For smaller organisations, there are likely to be different issues; for example, many SMEs have been found not to have explicit strategies, so it could be difficult to relate this to energy use (Inkpen and Choudhury, 1995). Notwithstanding this, SMEs represent an opportunity to undertake this type of work because strategy and energy are less likely to be managed by different people.

2.6.4 Evidence gaps

This section has explored the literature from the perspective of trying to understand SME energy management, how smart meter data-based interventions might help, and how SMEs are characterised more broadly. What hasn't been discussed in detail are the gaps in evidence, of which there are many.

First, the energy management literature is light on explicit SME-related studies. Much of the above borrows heavily from inferences made from larger organisation-focused research, and we know that SMEs are quite different in structure and operations.

Secondly, very little of the literature has explored the behaviours of organisations and how they relate to energy use, which seems like an omission, given that energy fundamentally supports their functional activities, so the two are deeply intertwined. Furthermore, whilst energy management studies have looked at energy, none of them appear to explore how SMEs manage other operational activities and broader performance, such as staff,

[30] The next section discusses literature on SME organisational strategies, where some researchers have discussed that SME goals can often be broader than simply making money.

productivity, profits and other aspects which are much more important priorities for them. There must be valuable insights from looking at these other aspects, but almost no references to these were found within the studies reviewed for this thesis.

Many of these broader activities are explored within other academic disciplines. A whole body of literature explores SME organisational strategy and entrepreneurialism, which has not yet been tapped into within energy management research. The value of this did not become evident until actually undertaking fieldwork within this study. However, it did appear extremely useful in practice, and so, because fortuitously this was an Action Research project, it was possible to adapt the study's focus to explore this area of the literature. This literature and its relevance is described in the sections below.

2.7 SME organisational behaviour and entrepreneurialism

2.7.1 Introduction

This section explores SME organisational behaviour and entrepreneurialism of SME owner-managers as described within business management literature. This has not been explored within the context of energy management research, so this section focuses on ways in which it could be helpful considering existing energy management research and evidence gaps described above.

One of the challenges with looking at organisational behaviour in SMEs is that it appears to be a challenging area, because of SME heterogeneity issues like those described in section 2.2; every business does different things to others. This is likely to be one of the main reasons why this hasn't been addressed in energy management literature on SMEs – other than within sub-sector specific research (Chester et al., 2020), which is by its nature harder to generalise from more broadly.

SME management research has looked at this issue for much longer than energy management researchers and this section shows how they have developed different ways of characterising SMEs so it can be conceptualised in helpful ways. As described further below, one approach has been not to focus on what they are doing but how they behave and make decisions to survive and thrive. Furthermore, when looking at SME owner-managers and their businesses – whilst they do very different activities, there are many commonalities in their business structures, and how they manage their businesses.

This section explores management literature and is structured as follows. First, the history of SME management theory is summarised, which helps understand what aspects are considered. Then, different ways in which SMEs have been characterised are described, including how they are differ from larger organisations and the role and agency of SME owner-managers. Then SME owner-managers goals, attitudes and behaviours are described, followed by descriptions of how they manage performance and make decisions. Finally SME organisational strategy and entrepreneurialism is described, including how this lens may be helpful to inform energy management.

2.7.2 Development of SME management theory

D'Amboise and Muldowney (1988), examined attempts to develop theories of small business management. They describe that it is useful to examine organisations from three distinct but complementary perspectives. First, the task environment, including around customers, suppliers, regulators and other involved actors. Second, exploring formal and informal organisational configurations and third, managerial characteristics, including goals, objectives and actions of the managers. This relates similarly to the frameworks described in the energy management literature by Janda (2014b) and Andrews and Johnson (2016), highlighting the importance of considering these different perspectives in theory development. That said, they also describe the importance of owner-managers in SMEs and that understanding their role and considerable agency helps to understand many other aspects of the ecosystems they inhabit. This is because, most of the time, they are in charge of setting the strategic direction of the business and managing operational activities and performance. This suggests that, whilst they are hard to engage in energy management issues (Bull and Janda, 2017), understanding their perspectives is crucial.

2.7.3 SME characteristics

A range of studies have explored key characteristics of SMEs, which help to describe their contexts and how they differ from large enterprises, which is helpful in better understanding the sector.

Liao and Welsch describe that their small size enables them to be ‘unfettered’ by bureaucracy and hierarchical thinking (Liao and Welsch, 2003) with typically short and often informal chains of command and having a ‘closeness’ to customers, and few delays between identifying issues and resolving them, which gives them advantages over larger

organisations (Bumgardner et al., 2011). Furthermore, their practice-based management structures make decision-making quicker and easier, with fewer principle agent problems (Sadorsky, 2008). Whilst they lack economies of scale, they enjoy pragmatic economies of scope, enabling them to excel in several scenarios, such as service provision (Anderson, 2000). While being small means that they are more vulnerable to market conditions, their size and often simple structures enable them to be flexible and adaptable to changing contexts (Irvine and Anderson, 2004, Zimmermann, 1995). SMEs are also challenged by having limited resources within which they have to operate. Time constraints, lack of planning and lack of ability to influence their markets are all described as factors which serve to make them largely reactive entities (Tocher and Rutherford, 2009). However, despite this, their strong sense of autonomy, ownership and informal management styles have all been described as critical factors in helping many survive over the long term (Turner et al., 2012). Finally, whilst SME resources may be limited, many are also characterised by how they can leverage networking and partnership with others to extend their resources (resource 'leanness'), where needed, often in ways which contrast considerably to large organisations (Jack et al., 2004, Jack et al., 2008, Turner et al., 2012). These factors, which are unique to SMEs and their potential implications for energy management are discussed further below.

The literature described from here on starts to explore entrepreneurialism as a phenomenon within SMEs. There are a great many definitions of entrepreneurialism, which have been developed and evolved by scholars since the 1700s (Long, 1983), however the Oxford Advanced Learner's dictionary provides a basic description of an entrepreneur as "*a person who makes money by starting or running businesses, especially when this involves taking financial risks*[31]", which is the broad definition applied within this thesis. What is more pertinent to this thesis is the question of what particular traits or behaviours make an entrepreneur entrepreneurial? Sarasvathy (2001b) introduces and describes 'effectual reasoning' as a rationality exhibited by entrepreneurs and how this relates as the inverse of 'causal reasoning', as a key ingredient of entrepreneurship. These traits and their development as theoretical heuristics are described in further detail in the sub-sections below.

[31] Oxford Advanced Learner's dictionary definition of an entrepreneur.

2.7.4 Organisational goals and objectives

As described in section 2.6.4, this is a key gap in SME energy management literature. Conceptually it makes sense to approach organisational behaviour from the perspective of understanding their goals and objectives as it can help explain energy-related behaviour.

There have also been few SME-specific studies exploring this in comparison to larger organisations which appear much more extensively researched (Ardley et al., 2016). The studies with SME organisational goals have described that they are often vague, inadequately defined, pragmatic and short-ranged (D'Amboise and Muldowney, 1988). Small businesses' activities are dictated mainly by their owners, who often play a very close role in their management, meaning that their goals often broadly reflect that of their owners. From this perspective, research exploring owner-managers motivations has found that they have broad goals, which often are not dictated by financial drivers (Douglas and Shepherd, 2000). Relatedly, small business growth often occurs in accordance with their owners' drive and abilities to achieve it (Cardon et al., 2012), and many stay the same size because they have decided to stay small, often for lifestyle reasons or to avoid complex challenges associated with business growth (Paul and Robert, 2000). D'Amboise (1993) describes that there has been a bias in the SME management research agenda to focus on growth and entrepreneurship, whereas few SMEs actually grow significantly over time. Several authors have described a culture of choice within small businesses, with many pursuing lifestyle goals, such as being one's own boss, freedom and control, respect, flexibility, informality and being able to interface family and work commitments. In combination, many of these characteristics and traits, which describe SMEs and their management, are described as radically different to larger organisations (Rappert, 1996). However, despite this, perhaps due to a lack of research focus, many frameworks exploring their behaviour are based on those of large organisations, as is described later.

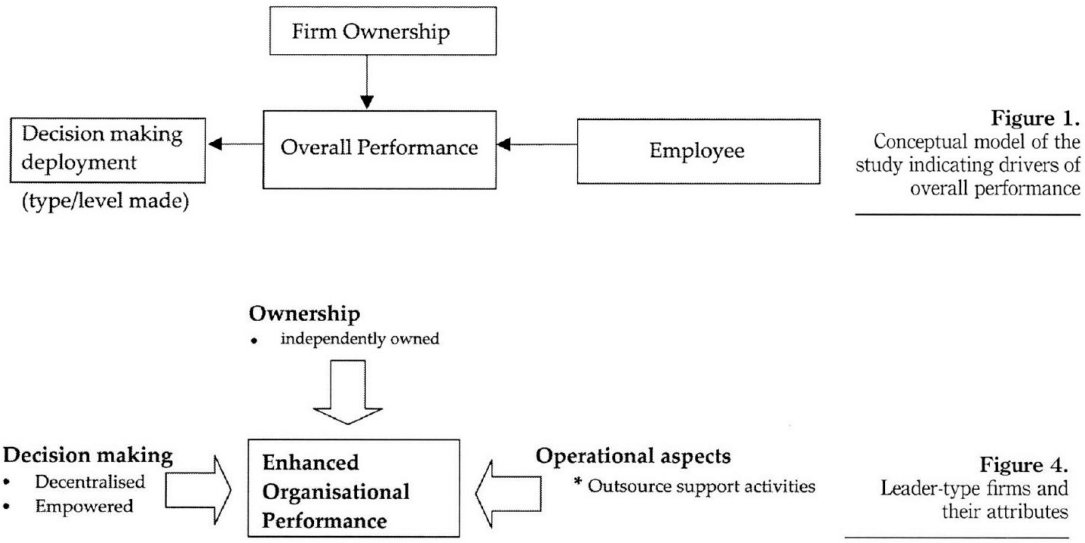
In summary, the evidence surrounding SME goals and objectives is heterogeneous, similar to that of their activities. The breadth of goals perhaps confirms that exploring them is challenging to do usefully; hence it is perhaps not so surprising that energy management research has not explored this before. However, it does help show the considerable agency of SME owner-managers and that looking at them as a lens to understand the sector is likely helpful.

2.7.5 SME performance management and decision making

If organisational goals and objectives are heterogenous (and therefore challenging to utilise as a framework for understanding energy-related behaviour), an alternative approach is to consider how SMEs manage organisational performance and decision-making. Decision-making is one of the critical drivers of organisational performance (O'Regan et al., 2005), which has been investigated by several small business research studies. Daily et al (2002) describe a distinct lack of consistency in what constitutes business performance in the eyes of SME owners and managers, which may well relate back to the diversity of SME drivers and goals described above. However, turnover and sales have been described as the most commonly used indicators of performance (Delmar and Wiklund, 2008). One study exploring performance metrics using focus groups with SME manufacturing CEOs found that overall a gross profit per employee was found to be most helpful because business size, structure, efficiency and communications all influence it (O'Regan et al., 2005).

O'Regan et al, explored performance using a sample of 75 SMEs, conducting in-depth interviews with their leaders, whilst investigating their financial performance over time, and described that ownership influences business behaviour to a large degree. They described that most leaders evaluated decisions through summary financial measures such as return on investment (ROI) and performance against budgets. They described that organisations well-performing or 'leader' organisations were more likely to be directly owner-managed and that less well-performing or 'laggard' organisations tended to be indirectly owned; for example, wholly owned subsidiaries of larger firms.

Figure 10 Conceptual model indicating drivers of overall performance (O'Regan et al., 2005)



This study found that leader organisations were strongly driven by overall organisational performance, maintaining a clear focus on their niche, sales and maintaining competitive advantage, whilst laggards were more focused on internal operational issues such as managing costs. They went on to recommend that independently owned businesses should continue to focus on aspects such as empowerment and creativity as a means of sustaining overall performance over time, and at the same time rigidly controlling costs, suggesting that the more successful organisations managed this efficiently by outsourcing cost control where possible (Figure 10).

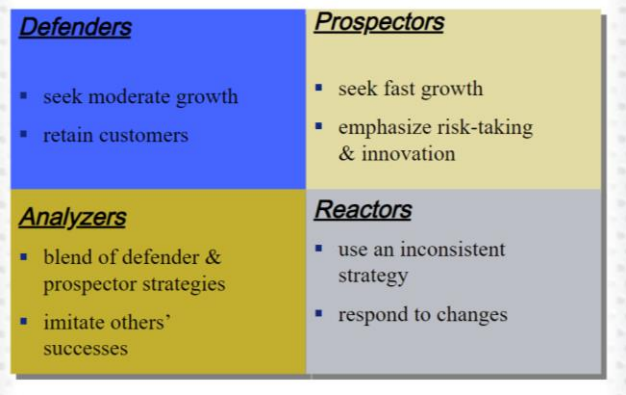
There are two implications here for energy management. First, this suggests that more successful businesses will, or should, pay less attention to energy management and ideally outsourcing it (which may help to explain some of the underlying reasons behind lack of interest in energy-demand interventions described in section 2.3). Second, this perspective is interesting as it looks at how decisions are made, not what those decisions are, which could be a way of exploring issues in a way which helps overcome heterogeneity challenges associated with the sector. The following section looks at this further; expanding decision-making into exploring broader organisational strategy and how SMEs make decisions to achieve their strategic goals.

2.7.6 SME Organisational strategy

Building on the decision-making perspective described above, several scholars exploring SME behaviour in the management literature have focused on organisational strategy. This does not make their goals the main focus of study but explores how they make strategic decisions to help them achieve their goals. This is of interest as, particularly when considering our interest in energy behaviours, arguably it is more beneficial to understand the means rather than the end, as it is in delivering these means where decisions get made that influence energy demand.

The Miles and Snow typology of corporate-level strategies (Miles et al., 1978) has formed the basis for many studies in management literature and continues to be one of the fundamental underpinnings of strategic business management (Hambrick, 2003). They postulate four basic strategy types within the business landscape, defenders, prospectors, analysers and reactors (Figure 11).

Figure 11: Adaptive strategies of businesses (Miles et al., 1978)



Defenders are businesses which seek moderate growth and prosper through stability, reliability, and efficiency. Prospectors seek fast growth by stimulating and meeting new product-market opportunities. Analyzers blend the two by purposefully being more innovative in their product-market initiatives than Defenders but doing so more cautiously and selectively than Prospectors. Finally, Reactors tend to prosper little as they apply inconsistent strategies and are mainly reactive to changes within their environment.

Whilst developed for larger organisations originally, over the years, it has been adapted, and there are studies which have described its relevance and use in SME contexts (Hambrick,

2003, Aragón-sánchez and Sánchez-marín, 2005, Ghoshal, 2003)[32]. One of the reasons for this typology's popularity is that it offers a simple and economical characterisation of the strategic stand of organisations (Hambrick and Crozier, 1985). Furthermore, it also enables scholars and practitioners to describe the strategic management of organisations in a generalizable way whilst also appreciating varied contexts and situations which is such a common feature within organisations. However, despite its popularity, this typology has been criticised for ascribing linearity and rationality to complex organisational phenomena (Inkpen and Choudhury, 1995). This criticism has been prevalent within SME research, and other theoretical frameworks have been developed to reflect smaller organisations' strategies better. One criticism of the Miles and Snow typology is that it is predicated on a traditional view of business development, whereby the decision-maker first sets a goal and then develops the means necessary to achieve it. Put another way, the logic of strategic planning is that a company starts with an analysis of its market and then subsequently creates and implements plans with clear achievement goals (Andersson, 2011). Because of this approach, these strategies have been described in the literature as 'Causal' strategies (Sarasvathy, 2001a).

Several authors have questioned whether this strategic approach applies well to SMEs who, as described above, often follow non-economic goals, are resource-constrained and operate in uncertain markets (Wang et al., 2007, Kemp and Gibcus, 2003, Bryant, 2007). SMEs are known to write down their strategies seldom, and furthermore, some organisations have been observed to have what has been described as an 'Absence of Strategy' in numerous situations (Inkpen and Choudhury, 1995, Robinson and Pearce, 1984, Beaver, 2002, Abosede et al., 2016, Wang et al., 2007).

Absence of Strategy

Inkpen and Choudhury (1995) defined Absence of Strategy as 'a firm not realizing an intended strategy or developing an emergent strategy'. Other researchers exploring this phenomenon describe these types of businesses as 'drifters' (Rodwell and Shadur, 2007). These are described as having no strategy as they do not focus their efforts in one area, or

[32] This is despite descriptions of their differences in characteristics and behaviours, such as those as described in the preceding sections of this review.

range of areas. They are also described as having no distinct patterns of activities that could be determined as following a strategy.

Inkpen and Choudhury (1995) describe Absence of Strategy as a phenomenon, arguing that even if a company has a product line or serves particular markets, this is insufficient to support the assumption that all businesses have strategies. Studies focusing on a Causation framework usually use the first three of the Miles and Snow typologies (Defender, Prospector, Analyser) as the basis for their analysis, and the Reactor typology is sometimes used to describe Absence of Strategy. However, Inkpen and Choudhury explored strategy absence explicitly and describe three types of Absence of Strategy. First, 'Absence as Failure', which usually leads to poor firm performance and eventually failure. Secondly, they describe 'Absence as Transition', where for example, a newly established firm does not have a history of decisions and is in a situation where a strategy is emerging over time. Finally, they also describe a situation where Absence of Strategy can occur as a 'Deliberate and Virtuous Void'. This can be where management deliberately builds in strategic voids as part of its organisational design. They describe where this can advantageous is in some scenarios, for example, in organisations facing a changing environment, where a degree of ambiguity may enable a firm to maintain an active and realistic set of strategic options.

From an energy management perspective, it is interesting to consider that Absence of Strategy is a phenomenon that occurs within SMEs. Given the lack of interest and activity surrounding energy management seen in the literature, it is perhaps worth considering whether energy management is an area where SMEs exhibit Absence of Strategy, which is something explored later within this thesis.

Effectuation as Strategy

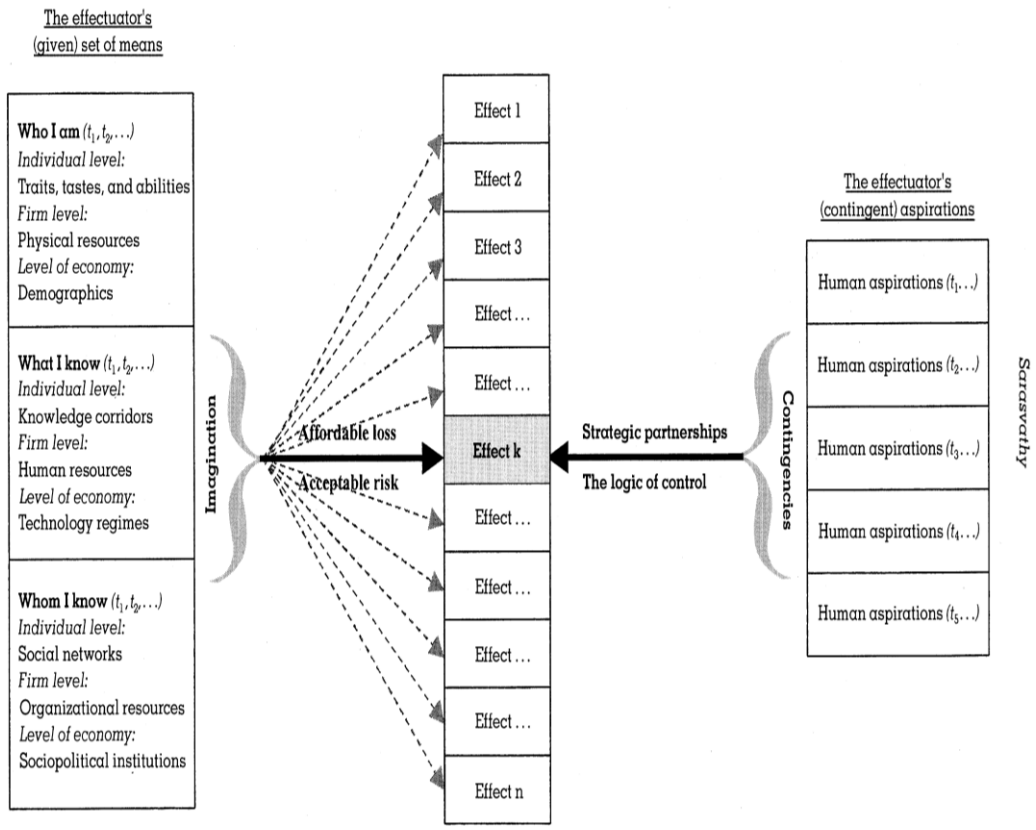
In order to explore strategies which did not appear to fit well with the traditional causal view of management literature, or Absence of Strategy, Sarasvathy (Sarasvathy, 2001a) developed another theoretical framework called Effectuation. Sarasvathy defines the processes of both Causation and Effectuation as follows: Causation processes take 'effect' as a given and focus on selecting whatever means are needed to create that effect. In contrast, Effectuation processes do the exact opposite; they take a set of 'means' as given and focus on selecting between possible effects that can be created with that set of means. She

describes Effectuation as a valid alternative to Causation, which often prevails when considering entrepreneurship and starting new small businesses. This is because small businesses and start-ups are most often resource-constrained at the beginning, which means that if one takes the Causal model of strategy, one would not have the means to undertake the planning activities and market research necessary to establish the presence of a market and the relevant opportunities and how to exploit them to get the business off the ground. Using an Effectuation approach, she describes decisions consisting of, first, a given set of means, which are the usually relatively unalterable circumstances of the decision-maker. Second, a set of effects or possible operationalisations of generalised aspirations are mostly generated through the decision process. Thirdly, constraints on and opportunities for possible effects are usually imposed by the limited means of the decision-maker and the environment within which decisions are being made (Figure 13). Finally, decisions also involve criteria for selecting between effects, usually informed by a predetermined level of affordable loss or acceptable risk relative to the means. Furthermore, in developing effectual processes and contrasting them to Causation, she developed a series of categories of differentiation between them, shown in Figure 12.

Figure 12: Contrasting Causation and Effectuation (Sarasvathy, 2001a)

Categories of Differentiation	Causation Processes	Effectuation Processes
Givens	Effect is given	Only some means or tools are given
Decision-making selection criteria	Help choose between means to achieve the given effect Selection criteria based on expected return Effect dependent: Choice of means is driven by characteristics of the effect the decision maker wants to create and his or her knowledge of possible means	Help choose between possible effects that can be created with given means Selection criteria based on affordable loss or acceptable risk Actor dependent: Given specific means, choice of effect is driven by characteristics of the actor and his or her ability to discover and use contingencies
Competencies employed	Excellent at exploiting knowledge	Excellent at exploiting contingencies
Context of relevance	More ubiquitous in nature	More ubiquitous in human action
	More useful in static, linear, and independent environments	Explicit *assumption* of dynamic, nonlinear, and ecological environments
Nature of unknowns	Focus on the predictable aspects of an uncertain future	Focus on the controllable aspects of an unpredictable future
Underlying logic	To the extent we can predict future, we can control it	To the extent we can control future, we do not need to predict it
Outcomes	Market share in existent markets through competitive strategies	New markets created through alliances and other cooperative strategies

Figure 13: The theory of Effectuation (Sarasvathy, 2001a)



[a] Effectuation begins with a given set of means and contingent human aspirations to select from a set of possible effects imagined by the effectuator(s). Both means and aspirations change over time. The particular effect selected is a function of the level of loss or risk acceptable to the effectuator(s), as well as the degree of control over the future that the effectuator(s) achieves through strategic partnerships along the way.

Effectuation theory has gained traction since it was first described by Sarasvathy for various reasons. Firstly, research with SMEs has shown that there are many scenarios where they do not display Causal strategic behaviour. As described above, many SMEs have been found to do little 'formal' strategizing, with few having written-down strategies in place, which raises questions about how they, therefore, are able to thrive and also whether they are undertaking strategic activities, but which are different to those captured by Causal frameworks.

From an energy management perspective, Effectuation is another interesting phenomenon which brings new perspectives on how it may be considered. Whilst it has not been explicitly expressed in this way, considering Figure 12, 'energy management' as a concept feels aligned to a Causal way of operating, as opposed to Effectuation. Perhaps this could help further explain why large businesses do it and small ones essentially don't (see section 2.3). Furthermore, if an organisation's activities and means are continually flexing and

changing all the time, this gives reasons why energy management in of itself is not a high priority. Even if it is costly, why bother looking at it, if you do not know whether your business will exist in the way it is currently set up in the short-to-medium term? Perhaps this is simply considered a necessary and 'affordable' loss (Figure 13).

Exploring Causation, Effectuation and Absence of strategy typologies together

Each of the above-described strategy typologies have relevance to SMEs, who, according to prior research, can display each of or multiple strategies at different times and in different contexts. As such, exploring each phenomenon individually can miss seeing the broad range of strategic decision-making approaches entrepreneurs employ in practice, which is a criticism that has been levelled at the Effectuation and Absence of Strategy frameworks (Hauser et al., 2020). This sub-section explores studies which have explored the interplay between them and then begins to consider how strategic decision-making could influence energy-related behaviours described earlier in this literature review, with a view to that informing the focus of this study and where it adds value.

Previous research has described an interplay between Causation and Effectuation within SMEs. SMEs use Effectual decision-making primarily in the identification and selection of business opportunities and switch to Causal logic during company growth (Read and Sarasvathy, 2005, Berends et al., 2014b, Ciszewska-Mlinaric et al., 2016). Some have described that the preponderance of Causal or Effectual decision-making varies according to the firm's size (Nummela et al., 2014). However, others have described different relationships, where the use of which approach has depended more on the 'context' of the decisions being made (e.g. new business development, vs maintaining existing business) (Nummela et al., 2014, Smolka et al., 2016, Vershinina et al., 2017).

Hauser et al (Hauser et al., 2020) undertook a recent study exploring strategic decision-making in SMEs, exploring all three types of strategic decision-making described in SME management literature; Causation, Effectuation and Absence of Strategy. The work aimed to undertake an in-depth study with a sample of SME leaders to empirically analyse their decision-making approaches, distinguishing between Causal, Effectual and Absence of Strategy reasoning and how they interrelate. They describe a general lack of empirical strategy research within SMEs. In undertaking the study, they wished to further explore

Absence of Strategy as a phenomenon to understand where and how it manifests within SMEs and how it differs from Effectuation, which they had identified as an explicit evidence gap. Building on previous research that firms exhibit different types of strategic behaviours in different contexts, the researchers selected four categories of contexts that have been associated with different strategic behaviours. As shown in Figure 14, these included founding (i.e. business start-up), takeover, new artifact creation (e.g. developing a new service or product) and maintenance of existing artifacts (e.g. operational management). They explored these through in-depth interviews with leaders of ten Swiss SMEs in the manufacturing sector. They used the findings to develop a framework for delineating the Absence of Strategy from Effectuation and Causation and they also explored, across the four contexts, when Absence of Strategy, Effectuation and Causation are most likely to occur. Within each of the three behaviour types, they also utilised coding structures, informed by previous studies for more specific behaviours exhibited; the codes and definitions of which are shown in Table 1. These codes were mapped according to five code categories, basis for taking action, view of risk and resources, attitude toward outsiders, attitude toward unexpected events, and view of the future. The specific codes and their definitions are set out in the table, and each describes different behaviours in the context of their code categories. For example, in the case of the category "basis for taking action"; the response relating to Causation is defined as 'goal-oriented' as it is goals, rather than means driven, aligning with the theory described above. In contrast, the response related to Effectuation is 'means-oriented', which they apply if an observed response is principally dictated by currently accessible resources (either within their organisation, or their broader networks). Finally, the response relating to Absence of Strategy here is called 'putting out fires', which is used in cases where a decision or action is principally driven by an unexpected event. Some of these codes and definitions have unusual names (e.g. Crazy Quilt), and it may be worthwhile for the reader to familiarise themself with them and their associated language as they are used to inform findings in subsequent chapters of this thesis.

Table 1: Codes and their definitions for the Causation, Effectuation and Absence of Strategy themes (adapted from (Hauser et al., 2020)).

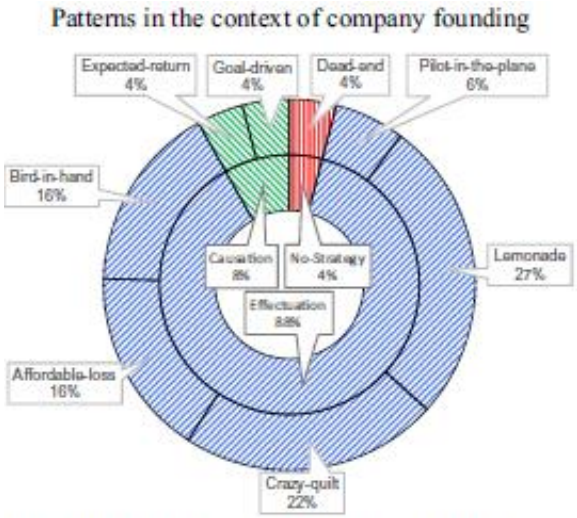
	Causation		**Effectuation**		**Absence of Strategy**	
Code Category	**Code /** (*name*)	**Definition**	**Code /** (*name*)	**Definition**	**Code /** (*name*)	**Definition**

Basis for taking action	Goal oriented (*goal driven*)	To what extent was the underlying driver for a project related to achieve a previously defined goal?	Means oriented (*bird in the hand*)	To what extent was the underlying driver for a project related to currently accessible resources?	Putting out fires (*putting out fires*)	To what extent was the decision forced by an unexpected event?
View of risk and resources	Expected return (*expected return*)	Calculating expected returns in order to choose from different options.	Affordable loss (*affordable loss*)	To what extent were risks and currently free cash considered in the decision process?	Dead end (*dead end*)	When something unexpected happens with a negative effect on the outcome and the company in general.
Attitude towards outsiders	Competitive analysis (*competitive analysis*)	Relying on plans, opportunity costs, and competitive analysis to reduce uncertainty.	Partnerships (*crazy quilt*)	Relying on partners, commitments, and communication to reduce uncertainty.	Walking alone (*walking alone*)	Relationships with stakeholders are not specified.
Attitude towards unexpected events	Avoid (*avoiding surprises*)	Avoid, overcome, or adapt to unexpected events.	Leverage (*lemonade*)	When something appeared to be different than expected, it was used to explore new opportunities.	Blinded by the light (*blinded by the light*)	To what extent were risks and possible returns not adequately considered?
View of the future	Predictive trends (*predictive trends*)	Socioeconomic trends and technological trajectories are seen as the prime driver of creating business opportunities.	Human agency (*pilot in the plane*)	Human agency is seen as the prime driver of creating business opportunities.	No-control (*no control*)	The future is seen as determined by luck and as such, every attempt to take control of it will fail.

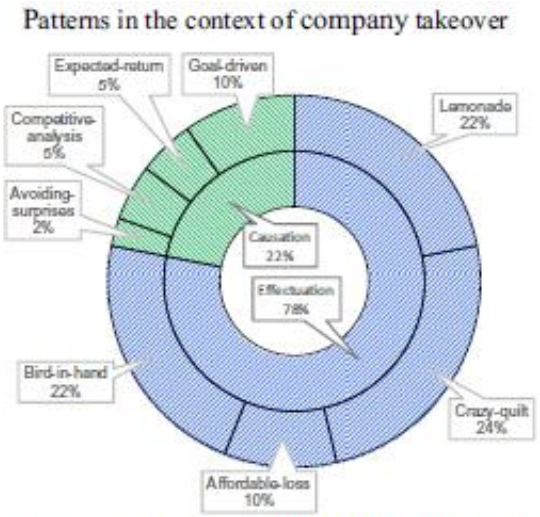
This study found, in common with other more recent studies, that SME strategic behaviour is dominated by Effectuation, and Causation and Absence of Strategy behaviours are rarer across all types of contexts studied (Figure 14).

Figure 14: Strategic approaches in different contexts (Hauser et al., 2020). Key to strategic behaviours:

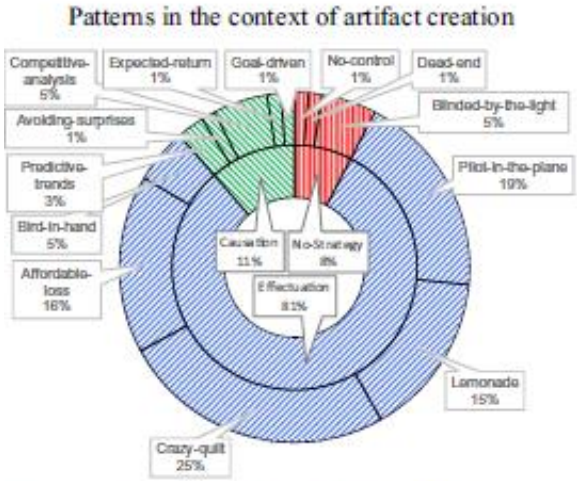
blue - Effectuation, green – Causation, red – Absence of Strategy.



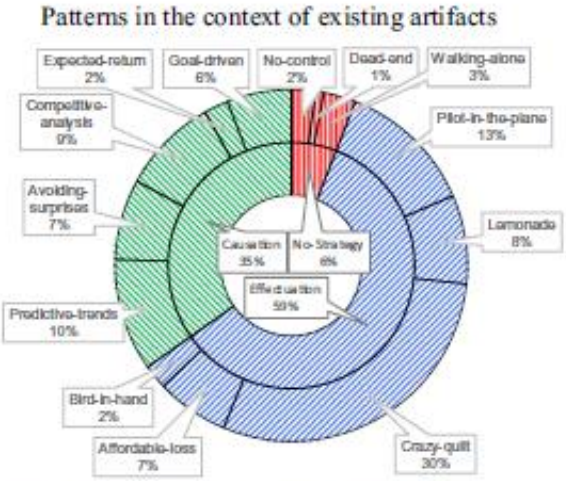
This context includes 49 codes from C01, C04, C05, C08, and C10



This context includes 41 codes from C03, C06, C07, and C09



This context includes 79 codes from C02, C03, C04, C06, and C07



This context includes 135 codes from C01, C02, C03, C04, C05, C06, C07, C08, C09, and C10

From an energy management perspective, all four contexts covered by Hauser et al (Figure 14) are likely to influence energy demand. However, new artifact creation and maintaining existing artifacts (see lower-left and lower-right pie charts in Figure 14) are likely to be the most influential, at least in a direct sense. For example, developing a new product or service will almost inevitably have energy-demand consequences. This has been identified through previous energy demand studies as key points at which opportunities exist to influence major energy decisions, such as the purchase of energy-using equipment or the design of systems which may use considerable amounts of energy (Kenington et al., 2019). However, these studies have not gone on to explore in any depth the drivers behind those decisions to try and understand how they might be possible to influence from an organisational strategy perspective. Exploration in this area should be enlightening to understand how these

decisions are made, and whether there are possibilities for improved energy management information derived from smart meters which could help influence these decisions.

Maintenance of existing artifacts is an area in which smart meter data could helpfully inform by helping make energy-demand more visible and measurable (Fischer, 2008) and, therefore, better manageable within a context which is relatively directly within the control of a business and where they often have processes in place to monitor performance. For example, there is evidence to show that some behaviours relating to Effectuation result from SMEs' small size and inability to influence and uncertain market environments they operate in; but that, given the opportunity, SMEs prefer to take approaches more related to Causation (Reymen et al., 2015). In other words, they like to have more control and be goal (as opposed to means) oriented where possible. In the context of energy management and smart meters, this raises the following question: Can smart meter data-based interventions help SME owner-managers to better understand and control organisational contexts, thereby enabling them to make more causally-influenced decision-making, which it is known they desire?

Overall, the approach taken by Hauser et al. (2020) to conceptualise entrepreneurs and their decision-making approaches appeared to be extremely relevant in the context of trying to help understand how to influence SME owner-managers to engage with and improve energy management for several reasons.

First, this framework focuses directly on the decision maker and how they make decisions, which is helpful from the perspective of interventions attempting to influence energy management. Secondly, as described later on in the findings, I discovered this entrepreneurialism framework whilst trying to understand better the ways in which Hildebrand made decisions in responding to the NDSEMIC Competition project (which were primarily Effectual). Experiencing these phenomena first-hand made it feel compelling to explore SMEs in this way. Finally, as well as this framework being potentially helpful to inform energy management, I saw that the literature here has been focused on influences on SME behaviour from the inside-out (i.e. actions of the entrepreneurs). It has not been explored from the perspective of an outside influence (such as that of an energy management intervention). Might SMEs use such decision-making frameworks to assess the viability of new opportunities and tools, such as energy management interventions? If so,

this might be useful as a way of helping understand how this works, which could reveal things about what is going on when they respond to interventions.

2.8 Summary

In summary, this chapter has reviewed existing evidence from which this study draws. It has shown that little is known about the energy-demand characteristics of SMEs; however, existing studies have indicated high variability in terms of energy demand and high levels of technical potential abatement. Their heterogeneity and small individual contribution to demand makes SMEs hard to reach and difficult to generate generalisable findings about, and they are relatively under-researched. The Climate Emergency means new research is needed to help inform how their abatement potential can be exploited to meet pressing Net Zero targets.

Looking at existing SME energy management practices such as billing and energy procurement indicates that few explicit connections are made between organisational activities and energy, despite it underpinning many activities they undertake. Smart meter data could help considerably improve such connections by making energy demand more visible and relatable to operational practices, thereby improving the potential for better management. However, very few SME-targeted smart meter data-based tools have been developed to date, which helps show the relevance of the NDSEMIC pilot in supporting market innovation here and the relevance of targeted research to help inform future energy management interventions.

SME energy management research identifies many barriers to energy efficiency. It has also highlighted the need to consider the complexities of organisational ecosystems, including the influence and roles of individuals (E.g. staff), organisations and their owners and the institutional rules, structures and contexts within which they operate, which a few helpful studies have considered to help inform theories, such as the 4Cs to help inform how to intervene helpfully.

Overall, the energy management literature relating to SMEs is very patchy, and almost no studies focus on broader organisational goals, activities and strategy and how these relate to energy. As energy fundamentally underpins organisational activities, this is a clear gap. This relevance became apparent during the first part of my fieldwork (Chapter 4), and led to

further exploration of business management literature and entrepreneurialism to help make this connection within the context of this study.

Exploring SME management literature identifies frameworks which help inform how SME owner-managers make decisions about their operations and future development in different contexts. These frameworks focus on the entrepreneurial SME owner-manager as fundamental actors' influencing organisational development and performance. They explore their activities as entrepreneurs and identify three decision strategies they employ in different contexts. Firstly, Causation; whereby goals are set at the outset and activities and resources are deployed to achieve those goals, which tend to be strategies more commonly associated with large businesses, and for SMEs in areas where they have high levels of control (e.g. maintenance of existing businesses and artifacts). Secondly, Effectuation; which employs 'means-based' strategies, whereby entrepreneurs evolve their goals according to the means they have available to them, leveraging these to help identify and exploit market niches, which often occurs when new businesses are established, or they develop new products and services (creation of new businesses and artifacts). Third, the concept of Absence of Strategy is the context within which entrepreneurs fail to develop or deploy successful strategies, which can lead to failure or transition into alternative activities. Recent empirical studies have shown that these strategies are employed by SME owner-managers variably and within different decision contexts (Hauser et al., 2020).

This framework is exciting from the perspective of informing energy management interventions. Firstly, whilst, as described above, energy demand is influenced and managed within complex ecosystems, SME owner-managers arguably have the most critical agency in the fundamental drivers of energy demand, so it makes sense to focus on them in this context. Secondly, this framework explores organisational behaviour and decisions within different contexts, which helps to overcome previously described heterogeneity challenges associated with the sector. Using such a lens could help to inform how SMEs will respond to energy management interventions in a way which relates to their organisational decision-making, which has not been done before. As is described above, the framework became apparent during the first part of this study (chapter 4), seeing how my Action Research participant colleagues from Hildebrand Technology responded to the NDSEMIC Competition. During the second part of the study (chapter 5), I used this framework to help

understand how SME owner-managers respond to a new energy management intervention and explore the potential of using smart meter and other data to help improve energy management.

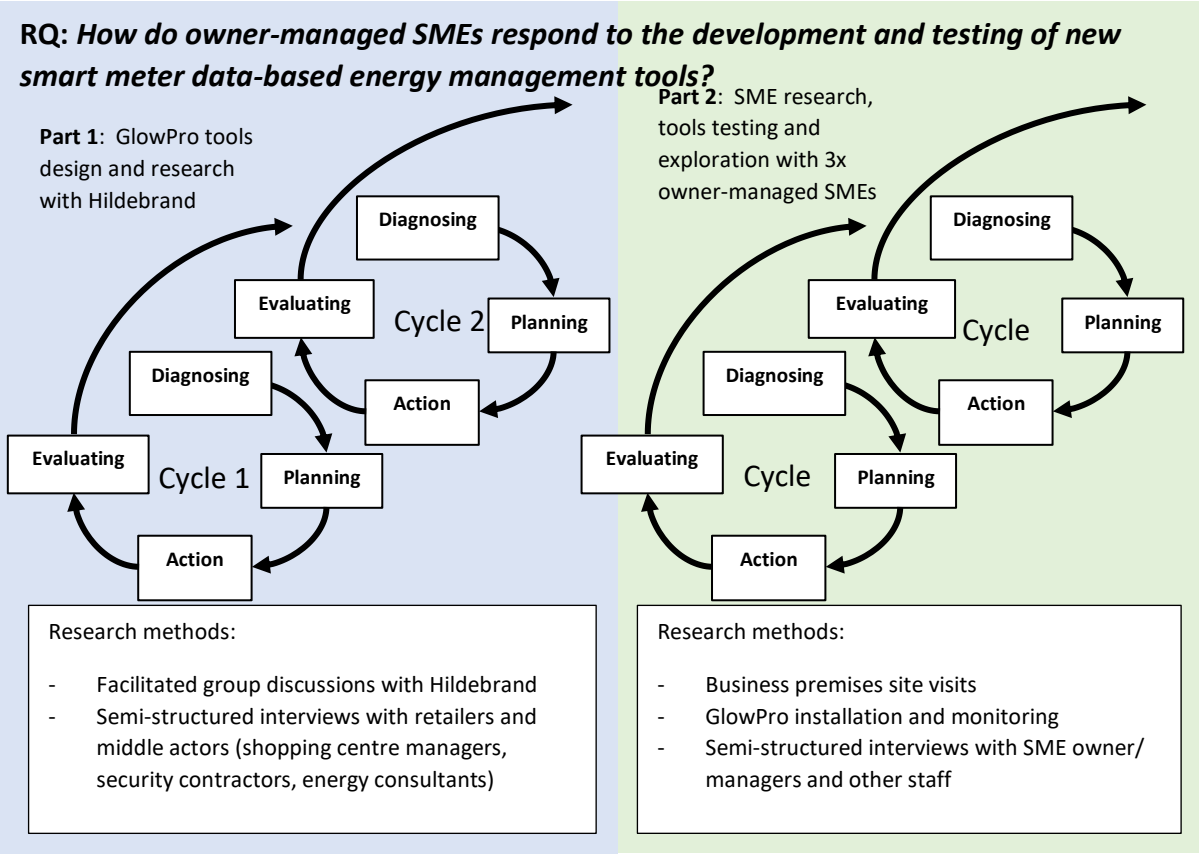
The following section describes the research design and methodology. Within this section, I describe the rationale for Action Research (AR) in the context of this study and how the approach was deployed.

3 Methods of inquiry

3.1 Introduction and overview

So far, the introduction and literature review chapters have introduced the intersection of energy management, SMEs and entrepreneurialism and why this nexus needs a richer exploration. They have also described the difficulties faced in conceptualising and conducting helpful research, which has led to this being an under-researched sector. This means that there are many gaps in understanding a) the characteristics and behaviour of SMEs in relation to energy demand and b) specifically how interventions can be designed to help them improve energy management. Exploring these aspects simultaneously is difficult, as the gaps in knowledge complicate an explanatory research design. Therefore, I chose to use Action Research (AR) as an appropriate exploratory method, the rationale for which is described below. I describe the research design in the sections below, including what was done and why. Figure 15 provides an overview of the research design, which included AR co-operative inquiry cycles (Heron, 1996, Heron and Reason, 1997, Reason and Heron, 2004), undertaken in two parts; the first working with Hildebrand as a team to inform the development of GlowPro, and the second working with three owner-managed SMEs to test the system and explore uses for smart meter and other data.

Figure 15: Research design overview: Co-operative-inquiry (Reason and Heron, 2004, Heron, 1996). **Part-1** collaborative research and design with Hildebrand (Chapter 4). **Part-2** testing and wider tools exploration with 3x owner managed SMEs (Chapter 5).



A detailed overview of the research activities timeline is provided in Appendix section 2.

The subsequent sections are organised as follows. First, I describe the rationale for the approach taken, introducing the Participatory Research Paradigm within which AR methodological frameworks are situated, the rationale for choosing AR and defining a role for AR in the context of SME energy management studies. This is followed by a more detailed introduction to the NDSEMIC Competition and Hildebrand, describing the broader context within this thesis. Subsequently, the PhD research question and supporting objectives are described, followed by the detailed methodology, including data collection, analysis and research practice, confidentiality, data protection and ethics.

3.2 Approach rationale

3.2.1 A participative worldview and why choose Action Research?

To understand how to influence behaviour-related energy demand, there has been increasing interest in understanding the social and cultural processes by which these arise (Roth et al., 2008). In the context of organisational learning, Roth et al. discuss the

development of an approach to problem-solving whereby discovering the most appropriate solutions is not seen as a collection of static entities, which can be dropped into a system to achieve desired outcomes. They discuss that knowledge should be gained through engaging with the dynamic social processes or interactions and feedback which occur within real-life contexts, which AR approaches enable. This way of looking at problem solving lends itself well to the context within which this study situated because; what is lacking is a good understanding of how interventions work or not and what can be done to improve their uptake and efficacy (see literature review, section 2.3).

Another reason for employing AR within this project was the nature of the Climate Emergency. While science has excelled at understanding the climate problem and identifying technocentric solutions, it has so far largely failed to seriously engage with the critical question of how to make transformational change happen at the pace and scale needed (Fazey et al., 2018, Umpleby, 2016). Aufenvenne et al. (2014) make the case that effective responses to climate change require a much more direct and concerted effort towards learning from and through action. They discuss that AR has considerable advantages in this regard as it focuses on learning about solutions and how they do or do not work, working directly with affected participants and enabling insights to be directly relevant and applicable. This also enables working at a greater pace than other more traditional research methods as it operates within the context of action.

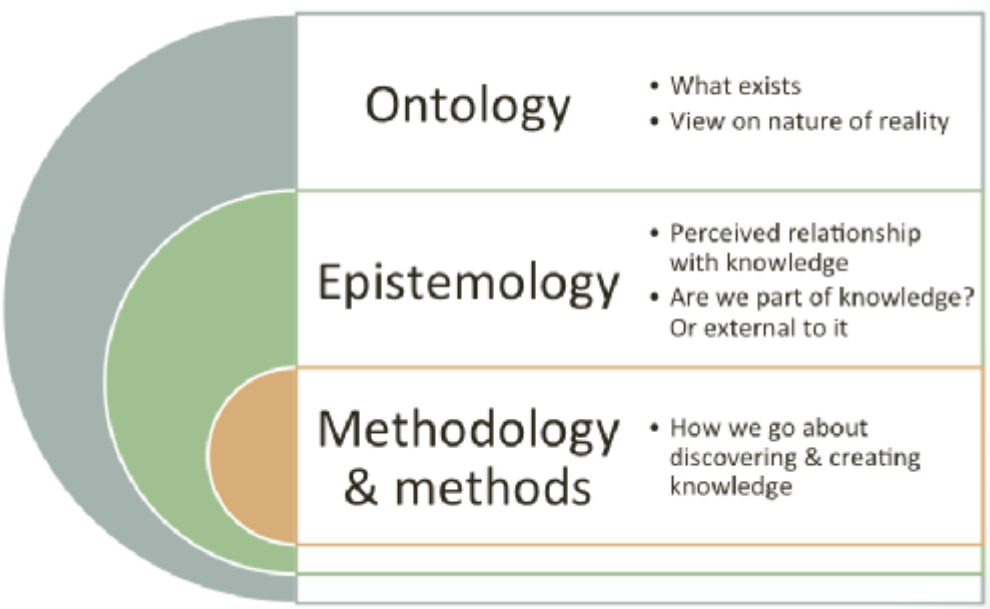
Before describing the approach taken for this study in detail, the following sub-sections describe the paradigmatic aspects of Participatory Action Research in order to situate the approach. This is described in some detail for two reasons. Firstly the detail is helpful to inform the reader about AR approaches and how they differ from other possible methodological choices, which could have been made (E.g. qualitative, case study research), and why AR was helpful in the context of this study. Secondly, elements of this are returned to within the discussion (Chapter 6), which helps lay the groundwork for that.

3.2.2 The Participatory Research Paradigm (PRP)

The concept of research traditions and paradigms was first discussed by Kuhn, who describes the collective assumptions, theoretical perspectives and ambitions which lead to distinct forms of research practice (Kuhn, 1963). In summary, research traditions include discussions about ontology, which refer to assumptions made about reality, and

epistemology, describing assumptions about how we come to know such a reality and methodologies, which describe the associated frameworks we use as social scientists to practice our research. Figure 16 provides a diagrammatic representation of the relationships between them.

Figure 16: Relationship between ontology, epistemology and methodology (Sandouk, 2015)



There has been a spectrum of research traditions developing out of our drive to achieve scientific knowledge about our world and dualistic thinking between the nature of reality relationship of the observer to it. At one end of the spectrum is Positivism, which implicitly assumes the existence of an external reality (object) which is understandable by an observer (subject) (Crotty, 1998). At the other end of the spectrum is Constructivism, an 'idealist' ontology first conceptualised by George Berkeley, who argued that 'reality' does not exist independently of the mind that perceives it (Berkeley, 1709).

There has been much criticism of Positivist claims to objective, value-free knowledge, especially within social sciences, for example, for its reductionism, contending that all social processes are reducible to relationships between and actions of individuals (Weber, 2004, Trombley et al., 2000). Conversely, Constructivism has also been criticised for its risk of solipsism, in that denying any kind of realism outside individuals' minds makes it very difficult to enact any solutions (Pihlström, 2020).

Between these two ontologies, a range of evolving research traditions occupies the middle ground. These include examples such as Critical Realism (Bhaskar, 2008), which derives from Positivism and Social Constructionism (Crotty, 1998), which derives from Idealism. Whilst different in nature, they both aim to acknowledge the existence of real social challenges outside an individual observer's realm, so it is impossible to justify inaction through relativism. Notwithstanding this, they also state that our knowledge is interpreted through social frames of reference, which means we need to give attention to a subject's perspective.

The Participatory Research Paradigm (PRP), which underpins AR, has similar philosophical roots to these, but what PRP does differently from these ontologies is that it makes an explicit link between object and subject, and that link is explicitly participative. Heron and Reason (1997) describe this participative ontology as where a concrete reality is not denied, but this is seen in relation to, and never separate from, the subjects, who are active participants in its continued creation (Heron and Reason, 1997). They discuss that an individual 'shapes' their interpretation of the world via their frames of reference or values, beliefs and assumptions. There is also a social influence on this process through a culture of shared language, values, norms and beliefs. Within these two areas, knowledge creation is viewed as a process of knowing, or in other words; learning. They then describe what they call the 'intersubjective field', which influences and is influenced by an individual's own articulation. Here the subject and object are in a continuous, evolving relationship and it is this participation which is fundamental to PRP.

3.2.3 Implications of this ontology for the concept of agency

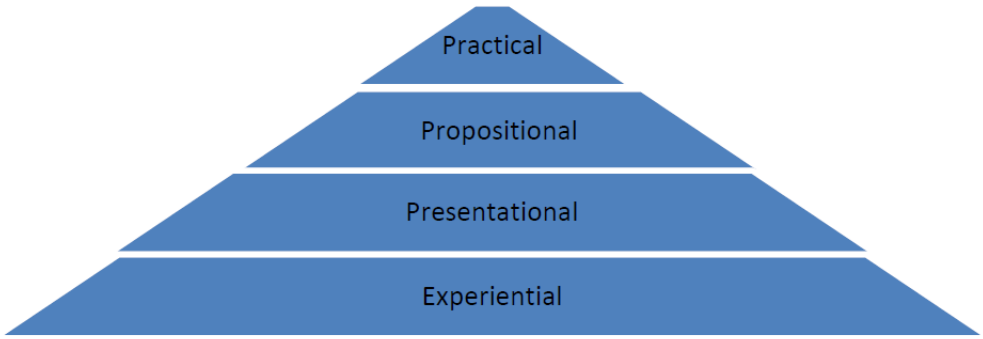
Connecting the subject and object in the way described above offers a response to the dualism of social sciences regarding the location of agency for change (Jackson, 1999). Kemmis describes how the PRP builds onto relational ontology whereby agency can be developed within it through communication. What this means is that, in a systemic world, everyone, researcher and researched alike, act according to social frames of reference and will reproduce these unconsciously unless sufficient attention is paid to communication processes designed to question and alter these. 'Critical reflection' is the term used for this process by many working in the PRP (Kemmis et al., 2015). Within PRP, the quest for knowledge should never be separated from experience. The research endeavour (or the

process of arriving at more complete knowledge) is therefore experiential and highly participative, as is captured in the epistemology advocated by the PRP, described below.

3.2.4 Development of knowledge through a participative, experiential epistemology

Heron and Reason describe how knowledge is developed in practice through the research process.

Figure 17 The four aspects of an extended epistemology (Heron and Reason, 1997)

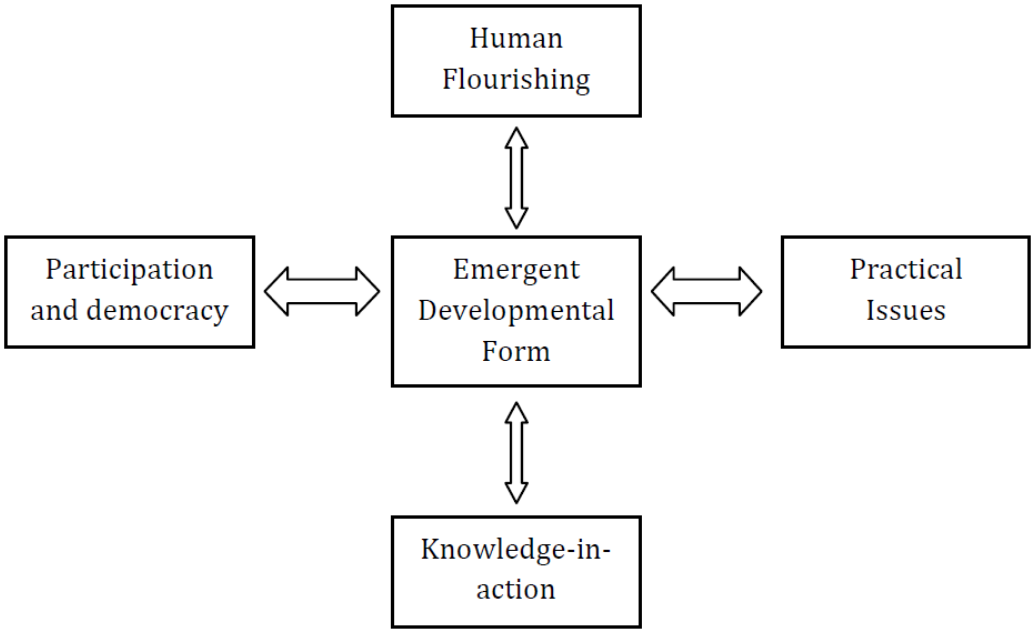


As shown in Figure 17, working from the bottom of the diagram upwards, Heron and Reason describe that experience is the primary source of knowledge and knowledge is not only a theoretical entity but a living process. So experience is the root from where understanding derives, which can be presented (presentational) from which it is then possible to make theories (propositional) and then finally act (practical). They then discuss the need for cultivating 'critical subjectivity', referring to an awareness of the four ways in which we come to know our world, understand contradictions or congruences, and understand the extent to which our practice really expresses our experience, meanings or propositions. This also includes 'critical inter-subjectivity', meaning an awareness of how our individual frames are related to the collective frames of our wider human communities. They say that if we concentrate solely on theoretical knowledge and deny the active, much broader process of meaning-making that takes place all the time and also guides our actions, we miss a trick.

3.2.5 The methodological frameworks of Action Research in the PRP

Action Research is the name for a broad collection of approaches undertaken within the PRP. Bradbury and Reason, two of the main proponents of AR methodologies, summarise that AR methods within the PRP appear to have five general characteristics (Bradbury and Reason, 2008), illustrated in Figure 18.

Figure 18 Characteristics of Action Research (Bradbury and Reason, 2008)



They assert that it is most important to adhere to these broad characteristics rather than to the specific details of what gets done (AR is methods agnostic, as discussed further in section 3.5).

AR is a participatory process concerned with developing practical knowledge to pursue worthwhile human purposes. It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally, the flourishing of individual persons and their communities.

Bradbury and Reason also talk about research being an 'emergent' process, so it is not appropriate for a researcher to provide a fully detailed research plan at the outset of a project and adhere to it throughout. To stay true to the commitment to participation and in recognition of the evolving nature of relationships within a study context, research must be flexible enough to allow creative responses along the way. However, this does not mean that a research project should not be planned at all. I followed this advice for this study by planning the approach in stages with review points so that I could consider what had been learned during my action and research activities and critically reflect on that to plan the next stage.

3.2.6 Quality and validity in Action Research

There is much debate about the notion of validity in social sciences associated with the different philosophical roots of the paradigms described above. Reason outlines how validity can be understood from the PRP perspective (Reason, 2006). He describes that as the PRP is influenced by many philosophies, including pragmatism and critical theory, it does not purport to arrive at a single valid 'truth', but it also does not deconstruct all versions of truth as in constructivist paradigms.

The PRP aims to develop theory about how best to act in a particular situation, linking intellectual theories with purposive action – called 'analogous theory building' (Reason and Torbert, 2001). So here, one needs to describe a theory about the situation now and what the desired situation is in order to inform action for progressing such a vision.

"to forge a more direct link between intellectual knowledge and moment-to-moment personal and social action so that inquiry contributes directly to the flourishing of human persons, their communities, and the ecosystems of which they are a part" (Reason 1996 p.189).

Here, Reason discusses the difficulties of trying to achieve reasoned behaviour from this perspective, describing that to help achieve this, you should involve not only the researcher's understanding of a situation but also place the participants' understanding as central and forge as close a link as possible with them during theory development. Furthermore, as shown in Figure 17 above, it must also be geared towards helping people to flourish and be active participants in the health of their own communities and ecosystems. It also needs to be flexible, accepting that these characteristics cannot be closely planned out in advance, referring to the planning issues described above. Finally, Reason also describes that quality comes not from viewing all of these aspects as criteria which can be externally verified but as signposts which remind us of the complexities involved in this. Validity in AR is viewed as clarity of intention provided within choices made to consider these ambitions as the research unfolds. As described further below, I followed this guidance closely during this study, for example by involving my research participants directly in discussions informing theory; I also undertook follow-up discussions after reflecting on lessons learned to explore and test theoretical concepts I had identified, including Causation, Effectuation and Absence of Strategy (see section 2.7.6).

Finally, to support this approach and to promote critical awareness and reflexivity in order to support validity, Reason and Torbert describe that we need to be clear in how we relate to the world and have clarity of intention in Action Research from three perspectives:

1. The self (first person) – which encompasses the "skills and methods that address the ability of the researcher to foster an inquiring approach to their own life, to act 'awaredly' and 'choicefully'[33], and to assess effects in the outside world while acting" (Reason and Torbert, 2001).
2. Co-researchers (second person) - involves creating communities of inquiry with others in which we are willing to explore the possible incongruities between what we say and what we do. This occurs when we inquire with others in a face-to-face group about our shared mission, our norms, and the quality of our individual performances on behalf of the team's mandate (Reason and Torbert, 2001).
3. Wider communities of shared interests (3rd person) - In third-person research, people come together to create an organization that provides the necessary conditions for people to engage in first and second-person research (Reason and Torbert, 2001). This thesis itself is the approach to engage the wider community.

These three perspectives are returned to within the discussion later on in chapter 6.

3.2.7 Dual level inquiry – implications for academic research practice

PRP seeks self-reflection on its own grounding assumptions because of its deep systemic perspective on knowledge and knowledge generation. A major characteristic of AR methods is that they have two goals to support this. First, solving a problem or problems in the context of what is being studied; second, contributing to scientific methods, thus requiring a dual level of inquiry (Coughlan and Coghlan, 2002).

Contextual-level inquiry**:** At this level, it means working in a context where issues are being explored that are of relevance to the study. For this study, it means placing my research within the broader NDSEMIC Competition looking at smart meter data solutions and whether and how they can help to influence energy management is important.

[33] These words, in the context of Torbert and Reason's descriptions here are interpreted to mean acting in a very self-conscious manner, so making careful and deliberate choices, and in doing so thinking critically about how they will influence the outside world.

Meta-level inquiry: Contributing to science and methods requires focus and reflection on the design and delivery of the approach; how it is designed, delivered and its findings disseminated – to help contribute to researchers' own practice (first person), research participants (second person) as well as for the wider research community (third person) who largely share this perspective.

This dual level of inquiry is reflected in my research question and objectives, which are described below (section 3.4).

3.2.8 Defining a role for AR in SME energy management studies

Whilst a few AR approaches have been undertaken exploring domestic sector energy demand (Petrova et al., 2017, Breukers et al., 2011) I did not find any explicit AR approaches that have been previously undertaken with SMEs in the context of energy demand or management. Some existing studies have similarities, for example qualitative, case studies focused on technology demonstrations or innovation projects (e.g. living labs), but none were found that explicitly embraced AR (Carlucci et al., 2017, Schwartz et al., 2015). Outside of energy management, AR is well known as being a suitable and helpful research methodology within a business context, mainly as it enables researchers to work 'within' a business and explore directly the effects of change with practitioners, in ways which would not be possible utilising other methodologies (Coghlan and Brannick, 2014).

However, as described above there is a very good case for doing AR here (Fazey et al., 2018). The literature review describes the small ND sector as being particularly challenging to research because of the nature sector's heterogeneous nature. Because of some of these challenges, the sector is often overlooked in terms of conducting research as it is often thought of as being in the 'very difficult' category for conducting valuable research (Lutzenhiser et al., 2002). Alongside, and likely because of this challenge, there is limited understanding of why small businesses tend not to respond well to existing energy demand interventions. Kurt Lewin, often acknowledged as the founder of AR described that "*you cannot truly understand a system unless you try to change it*" (Reason and Bradbury, 2008, Lewin, 1946, Burnes and Cooke, 2013). Within this context, AR may have a crucial role to play in helping to inform how to improve energy demand within small ND, as it involves getting directly involved with SMEs and effecting change, which enables the close study of

what changes that brings (and does not bring), which can serve to help problematise the issue in a way which is not possible using other methods.

As discussed later in this thesis (see chapter 6), one of the exciting aspects of undertaking AR in this subject area is that AR projects usually focus on issues that are explicit and substantive problems shared by those within the sector itself. These actors and researchers then collaborate to explore the issue and possible solutions. Bradbury describes that the broad conceptualisation for undertaking AR within organisations involves '*working with stakeholders, mobilizing teams, having dialogues with people who hold different views etc.'* (Bradbury 2015). However, as described in the literature review, energy demand in of itself suffers from a distinct lack of attention, such that it can be difficult to engage the relevant actors in the necessary active dialogue needed if there is a lack of sufficient shared interest. From a methodological perspective, it is therefore interesting to explore this type of issue using an AR approach to see what implications this has for using this method in this context and understand what challenges or methodological implications for future research it may reveal. Notwithstanding this challenge, relating to the contextual perspective, another aspect is of interest. What smart meter data can do is to make what has previously been largely invisible (i.e. energy demand) visible; so, its deployment within systems like GlowPro can help inform understanding about whether and how it can garner more attention to the issue of energy demand and influence action. The next sections provide a more detailed description of the NDSEMIC Competition and Hildebrand to describe the context the study was situated in.

3.3 Background and context to the study

This section provides context and background, describing how I became involved in the BEIS NDSEMIC innovation competition[34] and working with Hildebrand Technology Ltd, one of the Competition winners. An additional section in the appendix (Appendix section 1) further supports this chapter section. The appended section summarises how I became interested in small business energy demand and the personal and professional experiences that led to me undertaking this thesis. These motivations do not substantively contribute to the

[34] https://www.gov.uk/government/publications/non-domestic-smart-energy-management-innovation-competition

findings of the thesis; however, AR has an explicit focus on the agency and role of the researcher (see section 3.2.6, quality and validity in AR) and this section helps contextualise some of the discussion in chapter 6.

3.3.1 Non-Domestic Smart Energy Management Innovation Competition (NDSEMIC) background and context, aims and objectives

The UK Government is delivering the smart meter roll-out in through the Smart Metering Implementation Programme (SMIP), which is managed by the Department of Business, Energy and Industrial Strategy (BEIS). The programme obligates energy suppliers to deliver the roll-out, aiming to install approximately 53 million smart electricity and gas meters to domestic properties and non-domestic sites in Great Britain by 2025. The SMIP aims to provide consumers with "real-time" information on their energy consumption to help them control and manage their energy use, save money and reduce carbon emissions, bring an end to estimated billing, and make informed purchasing decisions reducing the barriers to switching between suppliers.

The roll-out includes over two million non-domestic sites[35], most of which are occupied by microbusinesses and SMEs. While Government anticipates energy demand benefits coming from these non-domestic sites, they have recognised that much less is known about how they use and manage energy and, therefore, how they might benefit from the roll-out. In addition to this lack of understanding, there are differences in the roll-out obligations for energy suppliers between domestic and non-domestic sites. One substantive difference is that whilst the domestic roll-out requires the provision of energy advice and an in-home display (Figure 5) to help consumers access and understand their energy consumption data, the non-domestic roll-out does not (Department for Business Energy and Industrial Strategy, 2021b). Furthermore, whilst suppliers must provide ND customers with timely access to half-hourly consumption data, they do not have to provide this free of charge (Department for Business Energy and Industrial Strategy, 2019a). As smart meters are shown to achieve demand reductions by making energy use visible (Fischer, 2008), Government and other

[35] Supply licence conditions require energy suppliers to install smart metering systems (or in some circumstances, advanced meters) at premises whose average annual gas consumption is below 732 MWh per year and at all premises in electricity Profile Classes 1-4.

stakeholders were concerned that this would reduce consumer benefits of the roll-out to the ND part of the roll-out.

The rationale for not mandating display devices and free data access for small ND sites was because there is a much broader diversity of ND building use types in comparison to dwellings. They range from retail to hospitality to small industry such that bespoke approaches for different site-types would likely be more appropriate in order to effectively realise desired ND smart meter consumer benefits. Because of this, ND smart meter licence conditions was left flexible. This means that at the time of this research, energy suppliers were only obligated to provide ND SMETS and AMR customers with access to their consumption data "upon request" and "in a timely manner". This meant that suppliers could charge for data access if they wished, and could also provide data in any format they wished[36]. This meant that should data not be provided to customers, there was risk to the achievement of the smart meter data-based energy saving benefits, as these benefits were fundamental to the case made for undertaking the roll-out. In response, Government decided to monitor the market closely to see whether, and if so what kinds of ND smart meter data-based tools emerged during the roll-out, and to develop additional strategies to encourage this, if necessary.

BEIS conducted a series of research projects to better understand those targeted by the ND roll-out and to inform how policy or markets could be developed to help maximise the benefits of the roll-out (Department for Business Energy and Industrial Strategy, 2017b). The research helped to inform a range of contextual and potential smart meter enablers, which could help encourage small businesses to take action to improve energy management (see chapter 2, section 2.5, literature review). These insights, alongside observations that there were few market-led smart meter data-based innovations appearing within the market for SMEs helped inform the business case for Government to develop and fund the £8.8 million NDSEMIC Competition (Department for Business Energy and Industrial Strategy, 2018c).

Between October 2017 and January 2018, I was asked by BEIS to undertake a full-time secondment with them to support them in finalising the design of the NDSEMIC innovation

[36] Furthermore, there was no specific definition provided as to what was meant by 'timeliness', which meant that it was left open to suppliers interpretation as to what might be determined as a reasonable timeframe.

Competition and launching it through an information day event on 30th November 2017. This occurred at the start of my first year of PhD studies, and I took a three-month study break to undertake the work.

NDSEMIC aims and objectives

NDSEMIC ran between 2018 and 2020, and focused on developing energy management products and services based on data analytics using smart meter data[37] for smaller non-domestic sites included within the smart meter roll-out. The Competition aimed to develop the market for and maximise the overall uptake and impact of energy management products and services to help secure energy demand reduction within target sub-sectors of the non-domestic sector, including retail, hospitality and, in the public sector, schools.

The summarised objectives of the Competition were to:

1. Develop innovative, tailored and easy-to-use data tools to add value to smart meter data and facilitate user engagement, use and understanding.
2. Develop tailored packages of supporting complementary interventions (e.g. advisory and training materials, case studies, methods for peer-to-peer learning), which drive the uptake and effective use of data tools.
3. Secure earlier and greater levels of energy management activity, leading to reduced energy demand.
4. Develop and strengthen the market for energy management products and services.

The Competition included gas and electricity meters in non-domestic premises within the Smart Metering Implementation Programme's (SMIP) scope. Due to the early stage of ND smart meter roll-out at the time, the scope of the Competition included both smart and 'advanced' meters[38]. As described above, the focus of the Competition was on developing tools to support small, and micro-businesses included within the scope of the smart meter

[37] References to smart meters and smart meter data also included advanced metering and advanced meter data.

[38] The functionality of a "smart meter" is defined by the Smart Metering Equipment Technical Specifications (SMETS). "Advanced meters" can vary widely in functionality, but must, at a minimum, be able to provide half-hourly electricity or hourly gas data to which the customer can have timely access and which is remotely accessible by a supplier.

roll-out. However, to meet UK Government innovation competition rules, the Competition did not explicitly exclude larger businesses from its scope.

My role whilst working for BEIS was to help finalise the internal business case for the project and develop these into Competition invitation to tender documents in preparation for its launch. This included the Competition invitation itself, targeted at smart technology innovation businesses, as well as finalising the design of a separate programme of research and evaluation to be undertaken alongside the Competition in order to maximise lessons learned (Department for Business Energy and Industrial Strategy, 2018c, Ipsos MORI, 2020). I also supported the launch of the Competition at a BEIS Information Day conference held in London on 30th November 2017 (Department for Business Energy and Industrial Strategy, 2017a).

The Competition was launched in November 2017 via an SBRI Competitive application process. Eight[39] organisations were awarded funding to participate in the Competition between March 2018 and January 2020. The Competition ran in three phases; phase 1 (March-August 2018) focused on new software and tools development; phase 2 (September 2018 – January 2019) feasibility and initial solution testing and phase 3 (February 2019 – January 2020) implementation and user testing.

The programme of research and evaluation described above was also tendered and the contract was won by a consortium of research organisations led by Ipsos MORI (Ipsos MORI, 2020). The research and evaluation programme was designed to track the Competition's delivery, conducting research with Competition winners and businesses while they pilot-tested their solutions to evaluate the Competition projects individually and in aggregate. The competition was also supported by a social research and action research academic, Professor Elliot Stern, from Lancaster University. BEIS were keen to test the use of an Action Research (AR) methodology within the research to help better understand how the interventions worked and lessons that could inform future policy. The inclusion of AR within the scope of the project got me further interested in AR methodologies, so I explored

[39] Although one organisation dropped out during the competition, meaning that seven completed the competition.

whether it would be possible to undertake the PhD using an AR approach, working with one of the winning competition participants.

Finally, since the Competition, Government has further consulted how best to maximise ND smart meter consumer benefits, which has resulted in changes to the license agreement, which now include the following provisions (Department for Business Energy and Industrial Strategy, 2021b):

1. An on-request data offer: A requirement to provide up to 12 months of historic smart meter data to customers, for free upon request. Suppliers much respond to data access requests within 10 working days, either granting access (where all legal requirements are met) or clearly outlining why the request has been rejected and next steps.
2. Awareness raising: A requirement for suppliers to raise awareness with customers about the routes by which they can access their smart meter energy use data for free.
3. A default data offer: This requires energy suppliers to provide or make available for free user-accessible energy use information to smaller ND customers with smart meters[40].

These updates occurred after the Competition concluded however, so they are not explored in any depth as part of this thesis.

In the next section, I describe the partner organisation, Hildebrand Technology Ltd, one of the Competition partners. The section describes their business, way of working and how I got involved with them.

3.3.2 Background to partner organisation: Hildebrand Technology Ltd and the GlowPro prototype

Hildebrand Technology Ltd[41] was a small, growing information technology and services business operating in smart energy and the Internet of Things (IoT). Hildebrand operates a service platform for large-scale sensor data, which is collected via sensor hardware also

[40] Information must be based upon the half-hourly/hourly (electricity/gas) data from their smart meter and regular enough to give customers insights into, and help them make informed choices about, their energy consumption.
[41] https://www.hildebrand.co.uk/

developed by the company. They focused on collecting energy monitoring and other data and using it to design and implement new solutions and ways to engage energy users, which helps them manage energy and other parts of their homes or businesses.

Their clients include energy suppliers, providing In-Home-Display (IHD) and customer feedback solutions, delivered as part of the domestic smart meter roll-out either as a white labelled service or using their own brand called Glow. They provide hardware for these solutions, including Consumer Access Devices (CAD), either with or without an IHD. They also work with other clients, including Local Authorities and Central Government, working both in an advisory capacity to support the design and delivery of new digital services, principally using smart meter data. They have about 15 employees; 10 work from a central London head office, and five in their Romanian subsidiary responsible for hardware design.

3.3.3 GlowPro prototype overview

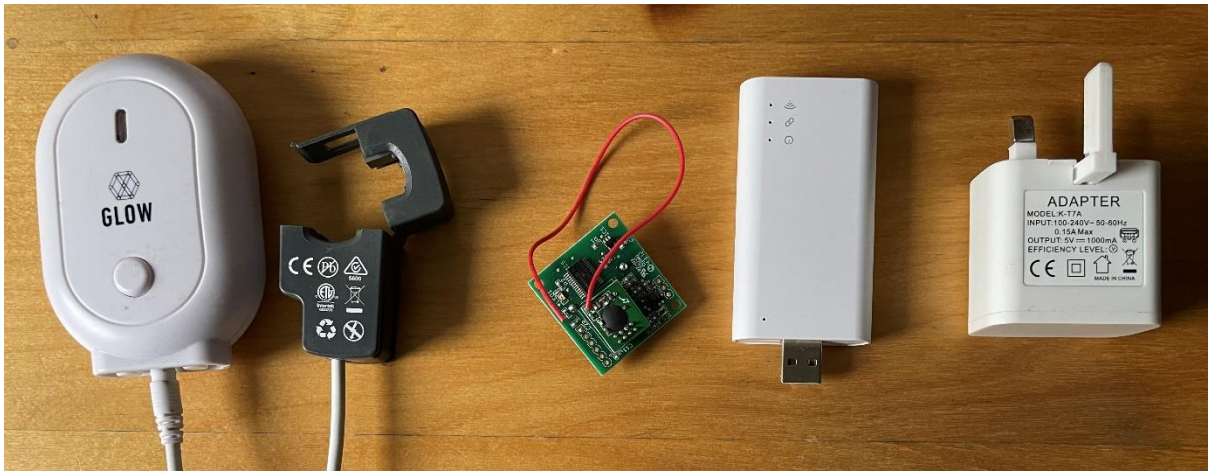
Hildebrand are registered as a Data Communications Company[42] (DCC) 'Other User', enabling them to communicate with SMETS2 smart metering devices. However, their monitoring and data collection activity started in 2007 before the smart meter roll-out, using hardware Hildebrand developed for an application called energyhive[43] (one of the world's first consumer interfaces to their energy consumption). The hub used a Wi-Fi-enabled radio protocol that communicated in real-time with energy clamps and transmitters, allowing customers to access their consumption data via a phone app or web portal without a smart meter. At the time of the Competition, the roll-out of smart meters to small businesses was in its early stages, meaning that finding organisations with SMETS2 to test solutions with would be very challenging. Because of this, the Hildebrand team decided to develop the prototype solution for this Competition using this proven clamp-based technology as a way to test the system concepts before incorporating actual smart meter data sourced via the DCC at a later date.

An overview of the GlowPro prototype system is shown below. Figure 19 shows the GlowPro hardware installed at an organisation's premises. First, the battery-powered current clamp data logger is installed (1) by closing the clamp around the main electricity

[42] https://www.smartdcc.co.uk/customer-hub/about-dcc-users/
[43] https://www.energyhive.com/

wire feeding into the electricity consumer unit[44] at the premises. Then, if an internal temperature logger is also required, that is installed at an appropriate location at the site (2). Next, the USB consumer access device (CAD) device is plugged in (3 and 4) in an out-of-the-way location but near enough to connect to a suitable Wi-Fi router on-site. Once the CAD is connected to Wi-Fi, the electricity and temperature data is collected onto Hildebrand's IT servers. Figure 20 shows how the data is then input into the GlowPro system architecture, and made available in a range of outputs, either through a smartphone App, or via a web portal. The system had differing types of access depending on different roles and interests of involved actors, such as premises managers and staff, owners and managers, and third parties such as shopping centre and facilities managers.

Figure 19: GlowPro hardware



1. Current clamp, battery case and data logger, which communicates with the CAD

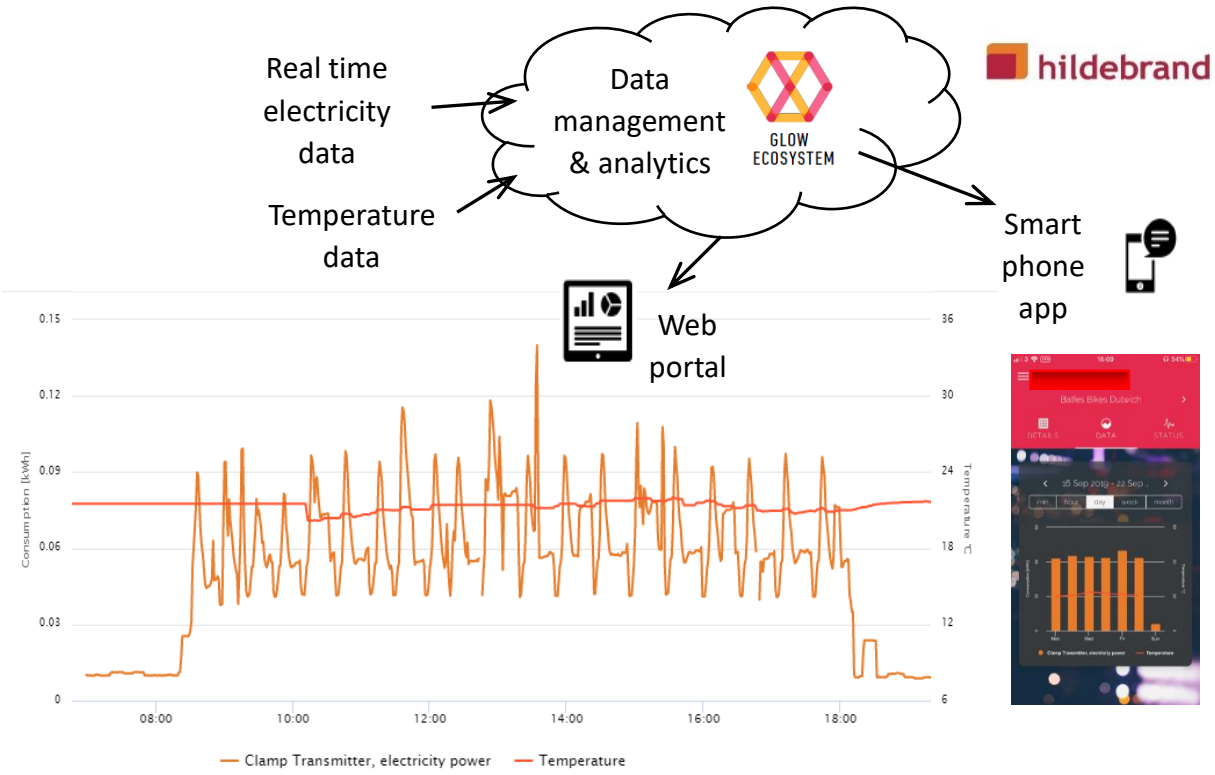
2. Temperature logger, which communicates with CAD

3. USB powered, 'Glow stick'; Wi-Fi connected consumer access device (CAD) data logger

4. Three pin plug power adapter, which powers the Glow stick.

[44] https://en.wikipedia.org/wiki/Consumer_unit

Figure 20: GlowPro prototype overview



The following section describes the study research question and supporting objectives.

3.4 Research question and objectives

As described in the introduction (chapter 1), my research question was as follows:

How do owner-managed SMEs respond to the development and testing of new smart meter data-based energy management tools?

Both parts to the research, and cycles of inquiry within them contributed to the overall research question shown above. As a reminder, the research question was also supported by the following research objectives, split between the contextual and meta-levels of inquiry (see section 3.2.7).

Contextual level of inquiry objectives:

1. Inform the design and deployment of GlowPro energy management tools.
2. Improve understanding about how energy management can be improved to deliver energy demand reduction.

3. Expand understanding about what other benefits (e.g. co-benefits) smart meter data-based energy management tools may deliver or whether it might be better to consider energy management as a co-benefit of other, higher priority actions.

Meta-level of inquiry objective:

4. Contribute to understanding about applying an action research approach in this context, learning about its strengths and weaknesses and developing recommendations for future work.

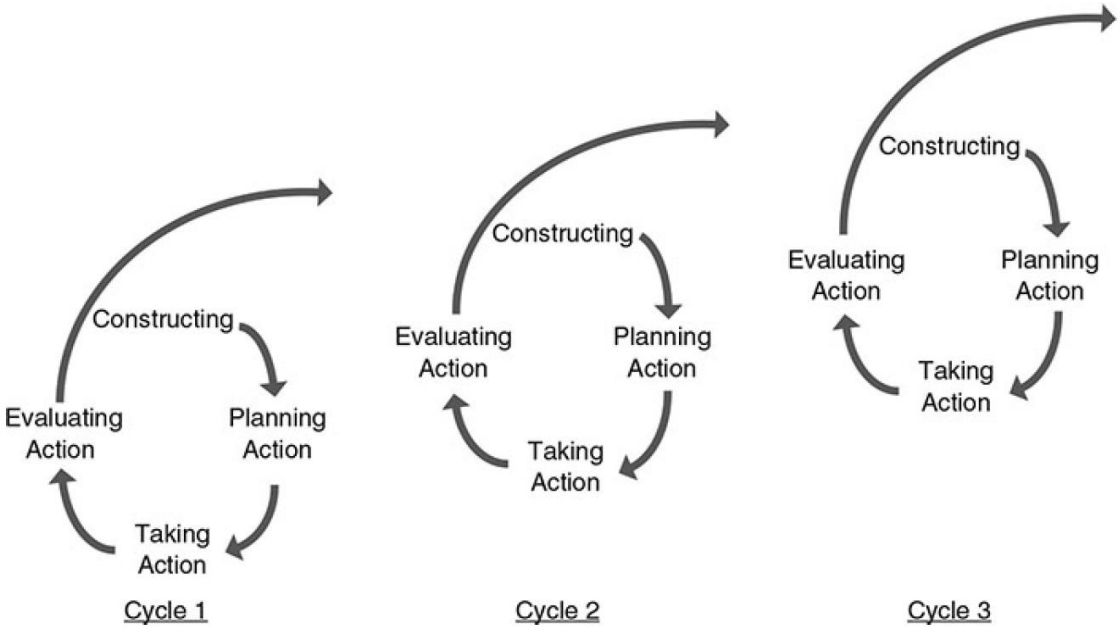
These research question and objectives served to scope and inform the main elements of my research. However, as AR emphasises action, my work was less centrally focused on these as other PhD studies are likely to be during the fieldwork. Aligning with AR methods, my focus was principally on knowledge gathering through a process of participative inquiry over time (Kidd and Kral, 2005). As such, rather than these questions singularly driving the project, I identified areas of inquiry that were relatable to my research question and objectives and also interested my participant co-researchers. I then focused on the methods to explore these together using cycles of inquiry, which are described further below (McTaggart, 1991). At the review stages within the inquiry cycles, I returned to the research questions and objectives to critically reflect on how insights were informing these questions and during subsequent analysis and writing up of the thesis.

3.5 Methods and data collection

This section describes the methods used to answer my research question and the objectives outlined in section 3.4. The methods and data collection follow AR 'cycles of inquiry' working co-operatively with my research participants. Each cycle, described by Coghlan and Brannick (2014) and shown in Figure 21, involves constructing, planning, taking and evaluating action. The evaluation stage serves to reflect on what has been learned, which subsequently informs future inquiry cycles, which are continued until the project concludes. Depending on the context within which an AR project is conducted, the project conclusion can be bound by time or resources or occur when the research participants feel they have sufficient insights necessary for their needs. AR is methods agnostic so long as the strategy employed contributes to the principles of the Participatory Research Paradigm (PRP) (Mcardle and Reason, 2008). Therefore there are various methodological tools available for

both primary research (e.g. interviews, focus groups) and secondary research (e.g. documents and reports review).

Figure 21: Action research cycles of inquiry (Coghlan and Brannick, 2014)



The first part of the project, described in findings part 1 (chapter 4), involved working collaboratively with Hildebrand, conducting co-operative inquiry as part of their team to inform the development of the GlowPro prototype during the NDSEMIC Competition. The second part, described in findings part 2 (chapter 5), involved further cycles of inquiry working with three owner-managed businesses, including a high street retailer (a small cycle-shop chain), a hospitality business (a small chain of coffee-shops) and a small industry business (a coffee roastery). Part 2 focused on testing the prototype GlowPro tool and exploring broader potential uses of smart meter and other data.

The purpose of this section is to describe the methods used in both parts of the study to answer the research question and objectives at both contextual and meta-levels of inquiry.

Perhaps the broadest distinction in specific social sciences research methods includes qualitative and quantitative interviews. Qualitative methods provide rich descriptions and explore people's thoughts and interpretations, which are generally suited to answering why-and-how-type questions. Conversely, quantitative methods concerned with counting and measuring specific phenomena are more suited to 'what' and 'how much' types of research questions (Creswell, 2009). Given the array of tools available, research methods specialists

recommend that in research design, very close attention is paid to the methodological choices made, given the research context and situation at hand, to ensure they can be deployed effectively to help answer the research questions and objectives. In an AR context, this is even more important as McCardle and Reason describe that AR is 'full of choices', which need to be made in different situations, so they place explicit focus on the process by which choices are made and how they fit the research context and questions, as opposed to on the methods themselves (Mcardle and Reason, 2008). I paid particular attention to this, developing research methods to align with my situational context working with Hildebrand and the owner-managed businesses within the inquiry cycles along the way.

3.5.1 The need for primary qualitative data

The research question that this thesis seeks to explore is how owner-managed SMEs respond to the development and testing of smart meter energy management tools. As described above, this is explorative, trying to understand issues faced by actors involved in designing and delivering new systems within the context of owner-managed SMEs. This makes qualitative methods the most suitable approach to use. As described in the literature review (chapter 2, section 2.6), and from previous experience undertaking energy demand research in this sector (Kenington et al., 2019), there is very little existing data and evidence on this, and what there is, is very context specific. This means that existing data is very unlikely to be of much use in informing the design of energy management tools. It was, therefore, necessary to go and explore these issues with people working on the project, both those developing the energy management tools (Hildebrand) and the audiences the tools were planned to be targeted at (owner-managed businesses).

In this chapter, I describe the choices of methods I employed, the rationale behind those choices and how they contribute to the findings and conclusions in subsequent chapters of the thesis. This also includes working with the UCL research ethics committee (section 3.7.3) to secure the approvals needed to progress the research and working with them to explore and address specific ethical issues related to my research.

3.5.2 Part 1: GlowPro development

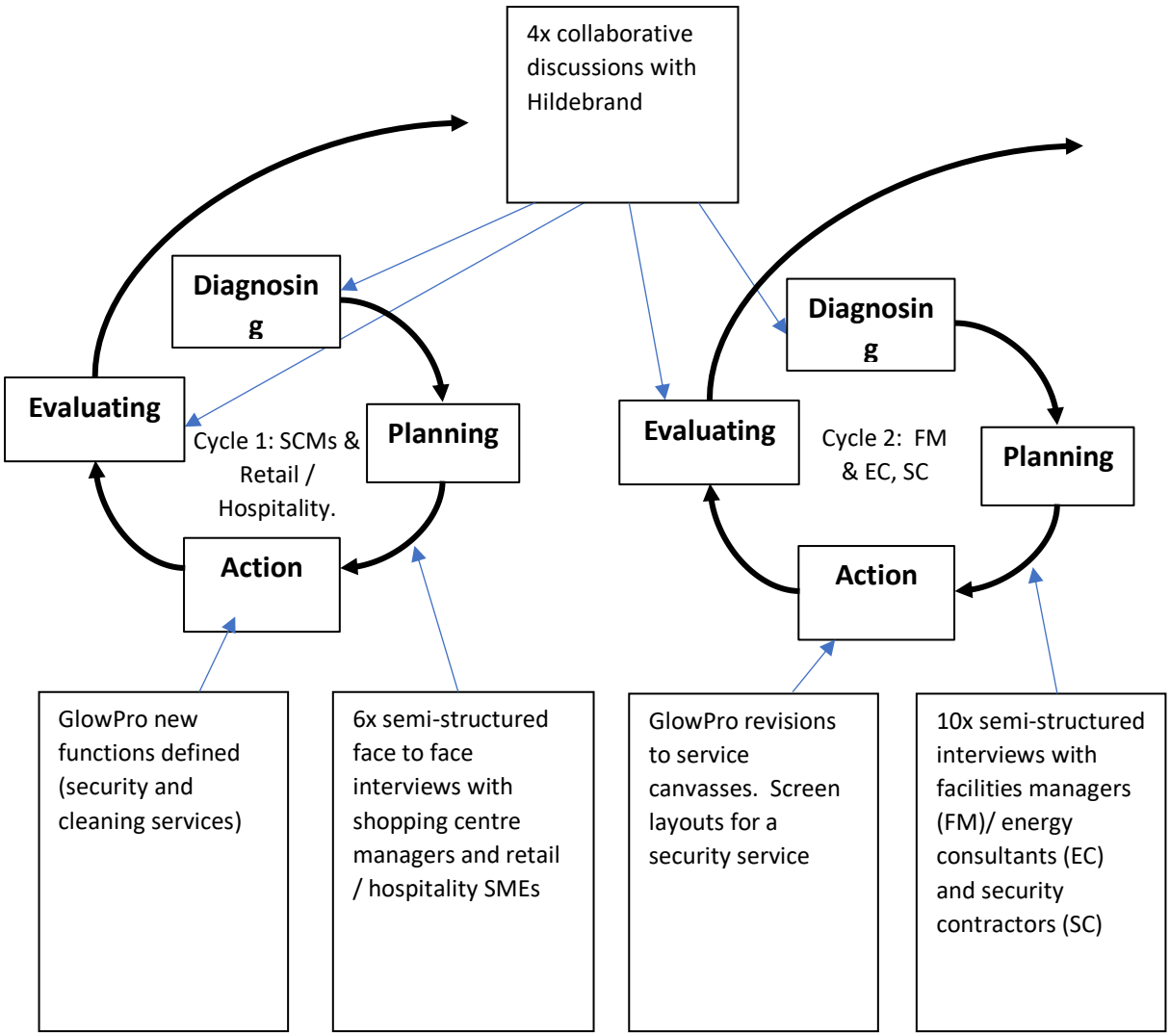
3.5.2.1 Overview and context

As described above, this first part of the research focused on informing the design and deployment of the GlowPro energy management tools and understanding what other

benefits smart meter data-based tools may deliver (see research objectives 1 and 3, section 3.4) at the contextual level of inquiry. This part also involved developing my understanding of applying an AR approach in this context at the meta-level of inquiry (research objective 4). Figure 22 provides an overview of the formal data collection approaches used.

Figure 22: Part 1 GlowPro research methods: Two inquiry cycles focused on GlowPro target audiences; 1) Shopping centre managers (SCM), retail and hospitality SMEs. 2) Facilities managers and energy

consultants (FM & EC), security contractors (SC)



3.5.2.2 Co-operative inquiry cycles

Below I describe what was done and how this relates Heron and Reason's work developing co-operative inquiry approaches (Heron, 1996, Reason and Heron, 2004).

As shown in Figure 22, part 1 comprised two cycles of co-operative inquiry in which I, as the outside researcher coming newly into the team, played a supporting role in a set of activities which had in essence, been set in place by Hildebrand as part of their response to the NDSEMIC Competition. Co-operative inquiry is a way of working with people who have similar concerns and interests to yourself to help understand your world, make sense of it and, together, develop new and creative ways of looking at this, lean how to act to change things to make things better (Reason and Heron, 2004). This is an AR approach, which is helpful to follow when working within a team in that it is concerned with revisioning our understanding of the world (i.e. theory) and transforming practice within it. When I joined

the group, we discussed and acknowledged that we brought different stakes and interests to the project. For example, I was interested in contributing to broader academic theory development through the project and supporting the team by providing research support and knowledge from academia. In contrast, Hildebrand colleagues were interested in learning about and leveraging existing theories to inform the practical development of GlowPro, helping increase its chances of commercial success. We explicitly discussed and acknowledged these differences up front. In doing so I was comforted by the team's openness, and they welcomed my input and contribution, not least because this meant that the dual goals of AR; solving a problem and contributing to science (section 3.2.7), were included (Coghlan and Abraham, 2018).

Developing a co-operative inquiry proposal: Heron (1996) recommends developing a formal proposal to develop, scope and seek agreement amongst the team working together. This was not done in a formal sense at this stage for a variety of reasons. First, as a new team member external to the organisation (and playing a supporting role), it did not feel appropriate to develop a formal proposal and seek agreement amongst the team. Furthermore, the team had a very informal way of working, and did not feel it necessary to do so. They felt they had already signed up to being part of AR as an approach in their response to the Innovation Competition as the Competition evaluators advocated it[45]. Hildebrand colleagues were very interested and open to the approach as they felt they could see how it could align with the usual approaches they took when developing new innovative solutions, described further in Chapter 4.

We formed a co-operative inquiry group, who all came together as co-researchers with common interests, albeit we brought a different range of skills to the table. For example, two team members brought previous social research experience (myself and Jane Wilson), while the other three had more experience and value to add to the actual GlowPro software and hardware development. We, therefore, worked together on different aspects of the problem and came together when there were lessons to be shared which had implications for the other. Here, we were working on developing a novel tool (GlowPro), which was targeted to be used by others (e.g. actors in retail and hospitality). As such, we needed to

[45] As described in section 3.3.1, the evaluation of the NDSEMIC Competition advocated an AR approach to that research, although this would be undertaken by the contractor (Ipsos MORI), not Hildebrand or other Competition winners.

plan actions, and that planning involved undertaking research, such as qualitative in-depth interviews with target users/actors interested in the tool, the insights from which would further inform the development of GlowPro.

Types of co-operative enquiry: Heron also distinguishes between types of co-operative inquiry which follow a highly planned and linear format, which he calls 'Apollonian' and those which allow for more spontaneity and emergence, termed 'Dionysian' (Heron, 1996) pp 45). Whilst, as described above, the approach in practice was undertaken in an informal way, the approach employed was more aligned with an apollonian approach. This was because many activities and goals were pre-determined by the timescales and constraints of the NDSEMIC Competition. That said, the activities enabled lessons to emerge, which subsequently informed what the next stage within each 'cycle' should comprise, which helped as none of the team (including me) had used an AR approach before in practice.

Heron also discusses the varying extents to which co-operative inquiry is truly co-operative. We worked together on the design and delivery of activities, including both conducting research as well as GlowPro system developments. However, much of this had already been pre-determined by the team before I joined, and also by the stages of the Competition, so the co-operative inquiry group is probably better to be described as being only partially co-operative. The group had decided they needed to undertake research already, and my contribution helped identify and suggest target groups to undertake interviews with and how they might inform GlowPro development.

In fact, some aspects of the focus determined by the group had arisen due to pre-existing relationships Hildebrand had with different organisations and the focus of their commercial interests. One of the challenges associated with this was that some aspects the team were focused on were not explicitly in the scope of my research areas of interest (or indeed the focus of the NDSEMIC Competition[46]), notably SMEs. For example, whilst SMEs formed part of their project (see section 4.2.2.2), the Hildebrand team were very interested in exploring the development of GlowPro with shopping centres, which tend to be occupied by large chains. This partly arose through existing relationships with some UK-based centres, for whom they provided a free Wi-Fi service for shoppers. This appeared a little problematic;

[46] Albeit, as noted in section 3.3.1, the NDSEMIC Competition did not explicitly preclude targeting of larger organisations within its scope.

however, owner-managed businesses were not excluded, and GlowPro focused on premises-level energy management, which could be occupied both by independents and chains. Furthermore, the opportunity to work with the team on this project was exciting, so I felt it worth accepting that some aspects of our interests were not totally aligned. Indeed, later on in the project, my interest and activities with SMEs helped the team as it supported delivery of their Competition activities in this area. As described in part 2 (chapter 5), I later developed a set of activities which enabled me to focus more exclusively on SMEs.

Finally, looking at it from a different perspective, I was also cognisant that Hildebrand was a very interesting and innovative owner-managed SME. I could also learn much from working with them, which is described in chapter 4.

Heron also draws attention to inquiry boundaries, discussing how open or restricted the topic of inquiry is. In this case, the exploration was focused explicitly on understanding potential market interests and needs to inform the design of GlowPro tools and how to make them as valuable to their target audience as possible. Through working closely with Hildebrand, the activities also enabled me to be an integral part of how they responded to the Competition and, in doing so, learn about how innovators respond to Competitions like this one.

Within co-operative inquiry, Heron discusses that some forms are restricted to understanding a context, and others attempt to transform it. Partially as a result of the narrow scope of inquiry undertaken here and the ability of the team to evolve and develop the GlowPro tools, this exploration sits within the latter camp. PRP advocates this transformative approach and perspective of knowledge generation as it advocates pragmatic attempts to transform a context as the most effective form of improving understanding. Figure 22 shows the main activities associated with the two co-operative enquiry cycles undertaken in part 1.

Theory building and testing: Two forms of theory building and testing were undertaken at this stage, with Hildebrand leading the first and me the latter, although we all contributed to each. The first related to a series of working hypotheses (Figure 23), which were used to directly inform the development of GlowPro (i.e. problem-solving), and the second was the building of an emergent broader theory with implications beyond the project.

GlowPro hypothesis development and evolution: Throughout the two cycles of inquiry (Figure 22), the hypotheses were central to informing pragmatic developments in the tools and were iterated. Once we felt we had gathered helpful knowledge to inform developments, these were developed (during the action stage). Then the hypotheses were reflected upon and new hypotheses were developed incrementally, working towards the finalisation of the prototype tool. The hypotheses had initially been developed following the previous exploration at the start of the Competition (prior to my involvement), and were generated from Hildebrand's previous experience working with the retail sector.

The broader theory-building work I led involved various activities, including analysis of the data I collected from being an active participant in the group discussions and other interactions with Hildebrand and our interactions with our target market, as well as the BEIS Competition funders.

As is described in further detail later on, I did not start with a theoretical framework with which to explore and test, but I used Grounded Theory as my initial approach to inductively inform theory building from data analysis (Glaser, 1967). As is further described below, this led to the identification of entrepreneurialism theory (Causation, Effectuation and Absence of Strategy, described in section 2.7.6), which I subsequently analysed deductively (see analysis section 3.6 for further details).

The following subsections describe specific activities undertaken collaboratively with Hildebrand within the co-operative inquiry cycles. Whilst it provides an accurate description of formal activities undertaken, it is worth noting that they were interspersed with many informal conversations between Hildebrand colleagues and me. Particularly during the research interviews and analysis of their insights, I was in very regular touch with the Competition project manager (Hildebrand COO Jane Wilson), speaking on the phone daily at times.

Cycle One - informing GlowPro development with retail and hospitality businesses

Below, the four stages within cycle 1 of the co-operative inquiry are summarised in turn (diagnosis, planning action, taking action and evaluating action (which informed cycle 2)).

Diagnosis: As shown in Figure 22, activities to inform GlowPro hypotheses to test were explored during facilitated discussions with the team, and Figure 23 shows the specific

hypotheses developed during the first inquiry cycle. These hypotheses all related to the contextual-level of inquiry (section 3.2.6) and were developed by Hildebrand during the first stage of the Competition (prior to my involvement).

Figure 23: Part 1, cycle 1 hypotheses for research testing

Three hypotheses were tested:

1. Retailers and hospitality businesses are not interested enough to fund/use a system which only serves energy management. The system needs to provide other benefits, too, in order to be viable.
2. The system needs to be designed to cater for very different needs according to the different organisation structures and roles and responsibilities of the users.
3. Shopping centre managers are a good target for implementing GlowPro in shopping centres.

The group sessions were mainly facilitated by Jane Wilson (Hildebrand) whose role was to manage and coordinate activities for the Competition project. As described above, Hildebrand had a very informal style of working, so these meetings tended to be relatively unstructured but usually started with everybody describing what was currently preoccupying them about the project and what needed to be done to design the following stages, including outputs and deliverables which the Competition required. We would then discuss each in turn and make plans to undertake actions that had been decided upon. I played a supporting role here, as I had little experience of being part of a team designing technology solutions; however, I did bring a helpful understanding of the ND sector and how it operates concerning energy management.

Planning action: The hypotheses informed the development of in-depth interviews, which were then carried out with specific actors (e.g. managers of retail or hospitality businesses) to help test the hypotheses and better understand their roles and whether and how the GlowPro system could be helpful for them. We would then recruit and undertake interviews with these actors and come together in subsequent group meetings to discuss what we believed we had learned from them and how the insights would be used to further

inform the development of the GlowPro system. As I was new to the team, I played an initial shadowing role in some of the interviews which Hildebrand led. These comprised:

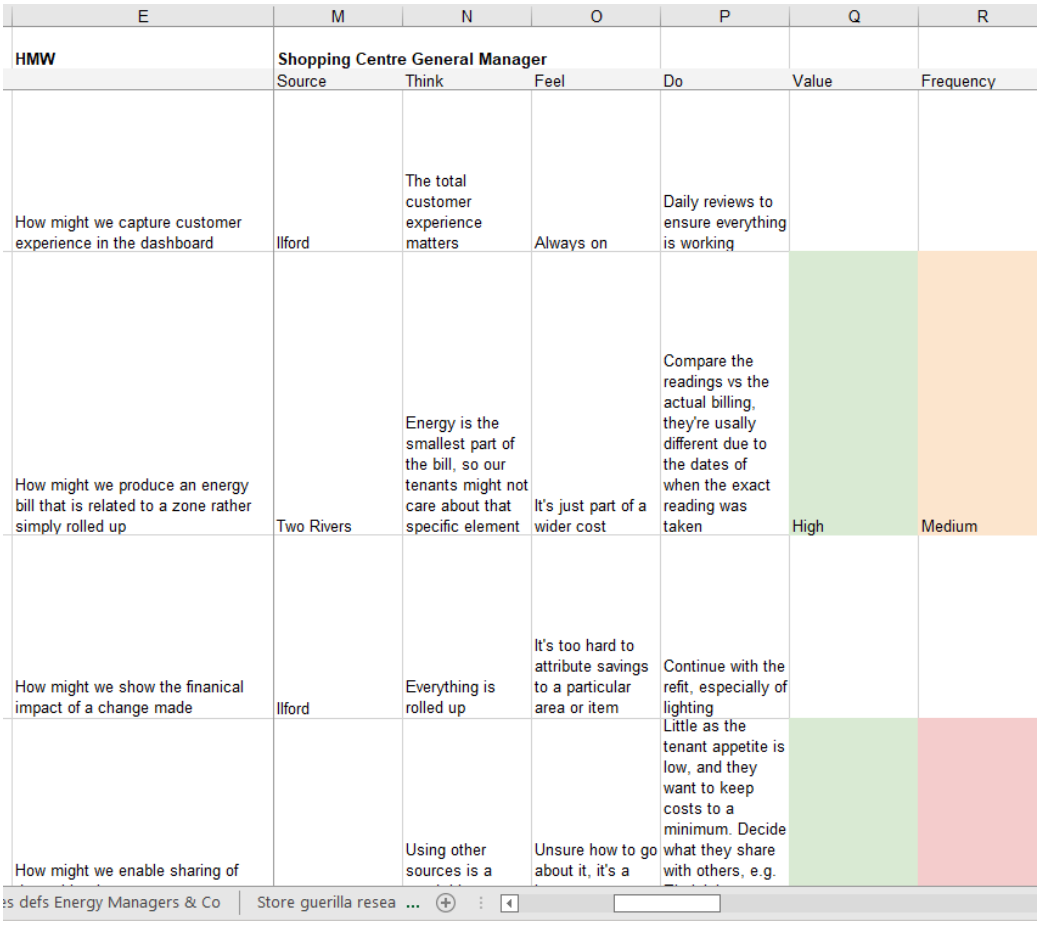
1. Three face-to-face interviews with owner-managed hospitality businesses in the local area (of which I directly participated in one) who were identified and recruited via one of Hildebrand's partner organisations who specialised in supporting the hospitality sector.
2. Three face-to-face interviews with shopping centre managers (of which I directly participated in two) who had been identified as potential customers of GlowPro as a system (see section 3.3.2).

Hildebrand had relationships with several retailers and hospitality organisations through existing activities and samples were drawn principally from these contacts and snowball sampling where appropriate (Goodman, 1961).

The interview discussion areas were developed by Hildebrand and explored each participant's roles, responsibilities and challenges they faced in undertaking their roles (see appendix section 4.1 for topic guides). The interviews were attended by two Hildebrand colleagues (and myself when I attended). We each participated in the discussions and wrote detailed notes. The interviews were not recorded as Hildebrand did not feel this was warranted and might alter the nature of the discussion as some commercially sensitive activities were discussed, which they did not want to compromise due to recording.

Subsequently, we came together to explore the insights gathered and how they could inform the further development of GlowPro. These ideas were collected together in the form of "How Might We" (HMW) statements (Figure 24), which Hildebrand's consortium partner applied as a well-known approach to creatively explore potential solutions while keeping the team focused on the correct problems which needed to be solved (Anderson, 2021). We each contributed to this activity in the form of further group discussions once the interviews had finished and I, again, played a supporting role with the team during these activities. The main output of this activity was a user requirements spreadsheet, which collated together the statements, which we then prioritised and considered how they could be incorporated into the further development of GlowPro.

Figure 24: Excerpt of "How Might We" statements developed following in-depth interviews informing further GlowPro system development



E	M	N	O	P	Q	R
HMW	**Shopping Centre General Manager**					
	Source	Think	Feel	Do	Value	Frequency
How might we capture customer experience in the dashboard	Ilford	The total customer experience matters	Always on	Daily reviews to ensure everything is working		
How might we produce an energy bill that is related to a zone rather simply rolled up	Two Rivers	Energy is the smallest part of the bill, so our tenants might not care about that specific element	It's just part of a wider cost	Compare the readings vs the actual billing, they're usally different due to the dates of when the exact reading was taken	High	Medium
How might we show the finanical impact of a change made	Ilford	Everything is rolled up	It's too hard to attribute savings to a particular area or item	Continue with the refit, especially of lighting		
How might we enable sharing of		Using other sources is a	Unsure how to go about it, it's a	Little as the tenant appetite is low, and they want to keep costs to a minimum. Decide what they share with others, e.g.		

Taking action: The interviews then led to further software (user experience) and hardware (e.g. introducing temperature sensors) developments within GlowPro. As I did not have skills in technology development, I did not get directly involved in these elements. Some examples of developments undertaken around this time included adding temperature logging capability and including temperature logging hardware to enable user-testing to include this feature. At this time, the team were also recruiting sites for user testing, including hospitality and retail chains. Because, at the time of the Competition, there were very few smart meters installed in the ND sector, Hildebrand developed a workaround prototype solution. This used current clamp installations to log electricity use and Wi-Fi connectivity to transmit the data to Hildebrand's servers, which were then used to inform screens within a desktop web portal and a smartphone app (see Figure 19 and Figure 20).

We then moved into the second cycle of inquiry, which started with the evaluation of cycle one and diagnosis of new areas for enquiry, including evolved hypotheses and areas for exploration in cycle two.

Cycle two - informing GlowPro development with middle-actors

Evaluation of Cycle One and Cycle Two diagnosis: Another facilitated group meeting was convened to evaluate the previous action cycle to inform the diagnosis of the second cycle of inquiry. These stages were done together for expediency as there was pressure on the team to meet the Competition's timeline requirements and their next funding phase. The discussion led to the generation of new hypotheses, which incorporated additional 'middle-actors, including facilities managers (FM) and energy consultants (EC) and security contractors (SC) (Janda and Parag, 2013, Parag and Janda, 2014). Middle-actors are actors positioned between Government (top) and individuals or organisations (bottom) who influence to promote societal changes from the middle-out (the middle-out perspective, or MOP). Together we identified during cycle one that these actors had an influential role in energy management (and therefore in GlowPro development), particularly within shopping centres, which warranted further exploration.

Planning action: We planned to undertake additional in-depth interviews with facilities managers and energy consultants (FM and EC) and security contractors (SC) to explore potential interests and uses for the system they might have. Because of previous experience I had working with these actors (from other work I had done prior to the PhD[47]) I got more directly involved in and led their sampling, recruitment and undertaking the interviews. Hildebrand colleagues were closely involved, with Jane, in particular, directly supporting developing the topic guides and also listening to, and participating in, some of the interviews. Because of my more significant involvement in this stage, I have described the sampling, recruitment and fieldwork approach in more detail here than for cycle one.

The in-depth interviews were sampled and recruited using a purposive strategy on the basis that the research methods are qualitative, with an emphasis on finding respondents who

[47] I had worked previously as a consultant on research and evaluation contracts for BEIS evaluating the CRC energy efficiency scheme, and the Public Sector Energy Efficiency Loans Scheme (Salix), both of which had involved interviewing facilities managers and energy consultants (CAG Consultants, 2014, Department for Business Energy and Industrial Strategy, 2018d).

are likely to be well-placed to participate in the research and who are likely to reflect similar views to those within the broader sectors (Creswell, 2009). Recruitment was undertaken through telephone calls and emails to participants, asking them to participate and tailoring these according to how I had identified and sourced specific contacts. I also used research information sheets and recruitment scripts (Appendix 0), informed and required by UCL research ethics processes. As they were believed unnecessary, no financial incentives were offered, and offering them may have induced response bias among participants (Creswell, 2009). Participants were encouraged to participate by highlighting the opportunity to be involved with Government smart metering initiatives, as well as the opportunity to influence the development of tools, which could benefit their work in future. Where appropriate, interviews included a description of GlowPro and its intended application to set the context for participants. However, it was decided to keep these descriptions high level to ensure a broad understanding of actors' activities and priorities is obtained, avoiding potential distraction and bias, which the team were worried may occur if GlowPro is introduced in detail too early (Furnham, 1986).

A topic guide was developed, building on those previously developed during cycle one and tailored appropriately according to the knowledge and experience of participants (see appendix, section 4.1). Question areas included:

1. Introductory context setting questions about the participants' roles, and any experience they had of smart meters / smart meter data, whether at work or within their home lives
2. Exploring their role at work and related tasks to understand the most critical aspects of their job, the problems they face and what strategies would help them overcome these.
3. How they engage with technology within their work, including smartphones and computers, exploring how they could interface with energy data, what would be useful or not and why. This included exploration more broadly than just energy, exploring what types of alerts and messages might be helpful to help them perform their role better.
4. Energy management-related questions, exploring what they do to manage energy (if anything), what information they work with and what they do with it. Issues they

perceive with energy management and exploration of possible information and other solutions which could help them.

5. Interviews were rounded off with exploring a hypothetical scenario where the participant had three magic wishes to create a technology-based management service, to suit their own needs, exploring what this would be and why. This was used to elicit broad thinking about the problems they faced, which could potentially be resolved using a data-based communication system like that being planned by GlowPro.

Following the same process as for cycle one, insights from the interviews, were once again developed into a prioritised list of HMW statements (Figure 24), which further informed GlowPro system developments.

Taking action: Once again, GlowPro software and hardware developments were undertaken, which I was not directly involved in. Examples of developments included additional screens tailored to security teams and improving the user experience of those accessing the GlowPro web portal and smartphone app. The team, at this point, was conscious of the need to finalise the development of a GlowPro prototype, which could be tested by a larger group of users, which was planned for the final phase of the Competition. As such, they focused on developing a semi-functional prototype, which did not have all of the access architecture and proposed user roles, but was a Minimum Viable Product (MVP), which could enable the system to be tested in practice. Finally, associated with this, at this point, a range of additional pragmatic developments took place. These included developing an 'installers' app, specifically developed to enable the team installing the prototype system at user's sites to efficiently install the electricity monitoring kit and connect the system to local Wi-Fi available at the premises.

Evaluating action: Once these developments had taken place, we came together again to discuss lessons and focus on how to work together to deliver the final user testing phase of the Competition. This evaluation session evolved into plans for part 2, which is described below.

3.5.3 Part 2: GlowPro testing; smart meter and other data exploration with owner-managed SMEs

3.5.3.1 Overview

Part 2 used the insights gathered about the GlowPro tools, alongside the development of the tool itself, to test it three owner-managed small businesses in the retail, hospitality and small industrial sectors.

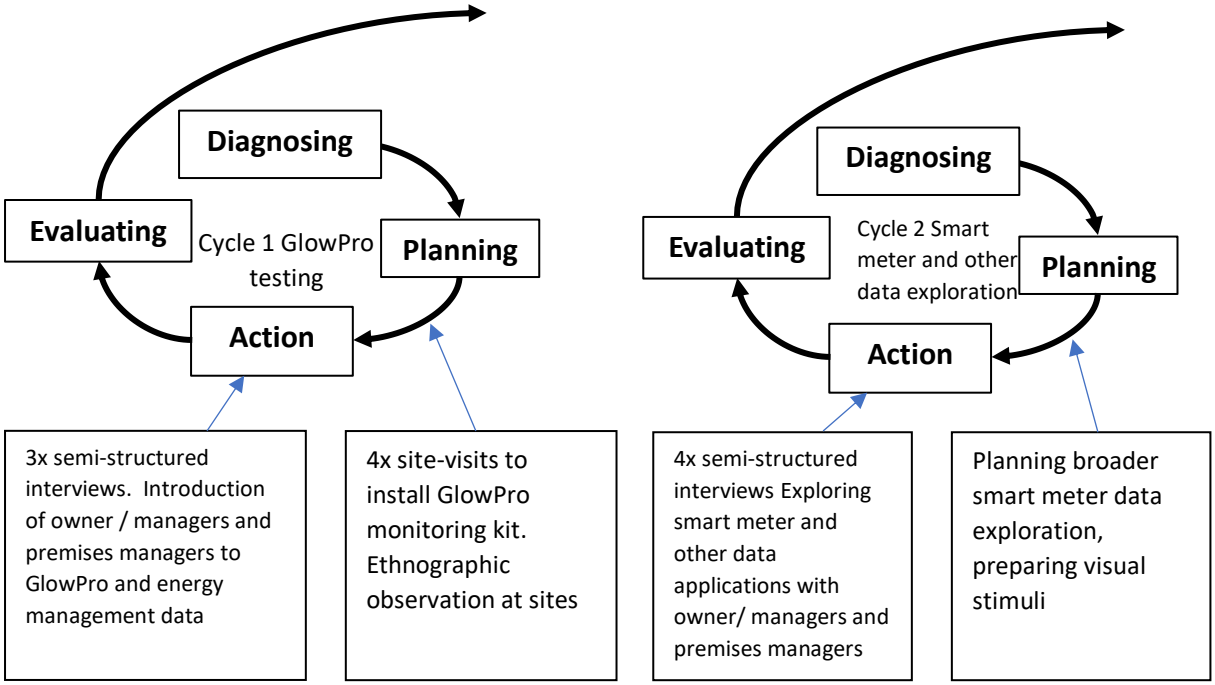
The context and focus of part 2 was different to part 1. Firstly, the semi-functional GlowPro prototype could now be tested with participants, gathering their experiences of the system and what it could be used for. Secondly, while I worked very closely with Hildebrand and their development team during part 1; part 2 focused on rolling out the system to a range of test participants, which comprised the final stage of the NDSEMIC Competition. Hildebrand allowed me to use part 2 to focus on working with small business owners and managers, to better understand how smart meter data-based energy management tools might be best designed and delivered to improve energy management (research objectives 2 and 4, see section 3.4).

At this stage, my relationship with Hildebrand had evolved as we knew and understood each other better, and their activities within the NDSEMIC Competition had also changed. For Hildebrand, this part was also focused on pilot testing GlowPro with various types of retail and hospitality organisations. From this they would gather feedback to inform whether or not to further develop GlowPro into a commercial proposition post-competition.

This gave me more limited opportunities to work with the team directly on further developing GlowPro as a solution in the short term. However, I was now better known and established with the team and they were happy for me to continue working alongside them for the rest of the duration of the Competition and subsequently. They also felt that whilst they planned to do limited further research themselves from this point, additional research and feedback (led by me) would be helpful for them to continue to deliver on their obligations for the Competition delivery and further inform their future plans for the system. From a pragmatic perspective, they were also happy for me to use GlowPro equipment to test the system with businesses I could recruit because these could help count towards their target number of pilot testing sites they had agreed with BEIS.

As described above, I used this opportunity to recruit a sample of three owner-managed businesses, each with different energy uses and approaches to energy management. I focused on undertaking AR with these three businesses, albeit maintaining regular contact with Hildebrand, which was used to disseminate insights from my research and further helped inform their Competition activities. Figure 25 provides an overview of part 2 research methods.

Figure 25: Part 2: Cycle 1; GlowPro prototype testing. Cycle 2; smart meter and other data exploration with owner-managed SMEs research methods overview



3.5.3.2 Reflections which informed part 2

Further described in the findings chapter (section 4.4), I learned a lot during part 1, which informed my approach to part 2. Below I summarise the main aspects of these reflections and how they influenced the approach.

One of the target audiences I was particularly interested in was owner-managed retail and hospitality SMEs, but as described above, this had been less of a priority for Hildebrand to date, so we had done relatively limited exploration with them. That said, they did have some interest in the audience (see part 1, cycle 1; section 4.2.2.2), and it certainly aligned with BEIS's main interests so it helped them if I explored this area further, as they could use these insights to report back to BEIS via their Competition reporting needs.

Given the low priority and attention many small businesses give to energy management (section 2.3), I knew I would have to be creative and flexible to gain and keep owner-manager SME participants' interest over time and for them to participate actively in the research. Furthermore, I was also aware that while the GlowPro prototype was now developed, it was a semi-functional prototype, and there might be issues when testing it and aspects of it were not designed to cater specifically for the needs of owner-managed SMEs.

Through critical reflections undertaken in part 1[48], I had also become more aware of how I communicated with my co-researchers and my own context and predispositions, which I inherently brought when working in an AR capacity and the different influences it can have (first person reflections, see section 3.2.6). I knew that this would influence what occurred, but through having greater experience doing AR in practice, I was now more aware of it. I, therefore, factored in and reflected upon how I communicated at each stage and the potential implications of this. For example, I had learned that Hildebrand had uncovered some new and entirely unexpected potential uses and benefits of the GlowPro system (described in chapter 4), which appeared to have arisen because of their very broad approach taken within the research. This involved taking care not to focus explicitly on energy management and potential solutions (which would unlikely have occurred if I had been leading the research process).

3.5.3.3 Retail, hospitality and industry owner-managed small businesses sampling and recruitment

I set out to sample and recruit owner-managed small businesses. Informed by the literature review, I had two sampling priorities. The first was to work with owner-managed SMEs, because most SMEs are structured like this (Ng and Kee, 2018) and that also would mean I would be engaging with participants who had direct control over their businesses. Secondly, I wanted to include a range of organisations to enable exploring differences according to known influential factors such as energy intensity, so I looked to include some businesses with relatively higher energy demand (e.g. in hospitality, small industry) and those with lower demand (e.g. non-food retail).

[48] Described in detail in section 5.5.

To achieve this, I not only needed to find organisations fitting this profile, but also needed access to their sites and spend time interviewing them. I wanted to secure their time and participation over a significant length of time, conducting interviews with them and their site managers in stages. I anticipated this to be challenging given the time-poor context of retail and hospitality businesses, particularly given the challenging context of retail stores at the time, with powerful competition from online retailers. I felt that this would be a big and likely unrealistic ask of organisations I simply approached directly, given what I had learned from previous research, albeit I thought I could build on and use lessons I gathered through previous less intensive research I had undertaken with retailers before (Kenington et al., 2019).

I knew an ex-colleague, Josephine, from a previous job who had moved on from working in energy to develop a coffee business, both setting up and running coffee shops and working in other aspects of the coffee industry. I got in touch with her to explore whether it might be possible to work with their businesses. After an initial meeting with Josephine and her colleagues and explaining in some depth what I wanted to do and why and why it might be an exciting exploration we might both learn from, they agreed to participate. What was fortuitous about this was that Josephine explained that they were involved with several different businesses, including a small chain of coffee-shops as well as a Roastery, which was a small industrial and manufacturing business. The Roastery specialised in roasting high-quality coffee beans for wholesale and retail supply (amongst some other related industry ventures). Through discussion, we identified that the coffee-shops and the Roastery businesses would be the most interesting to get involved with, so I decided to focus on these.

They provided me with access to them and their finance team, who oversaw the operation of both businesses. They agreed that I could use the GlowPro prototype to monitor one coffee-shop and the roastery business premises, which were situated in the South West of England, and talk to a range of colleagues within their business over time. Josephine agreed to be their primary contact, and as Chief Operating Officer (COO) of their business, she had very good influence of the sites and staff within the organisation. The organisation's structure was that they had an overall group holding company (which Josephine worked for), with a range of subsidiary companies, which comprised five businesses, of which one

included the SW coffee-shop and another the Roastery. All their 'back-of-house' operational activities were led by the group holding company (e.g. billing, maintenance etc.), whilst they enabled the separate businesses to largely be in complete control of their own operations and specific activities. Further details of the business structure is provided later on in chapter 5.

I viewed the opportunity to work with the coffee-shop and Roastery businesses as an excellent one; however, I was concerned that if, for whatever reason, they decided not to participate in the later stages of my work, I was keen to have some backup options. I therefore recruited two additional organisations. The first was a bicycle maintenance and sales small chain, who I also had a pre-existing relationship with through my previous research with high street retailers (Kenington et al., 2019). The cycle-shop had been a keen participant in my previous research, but had taken less part in that project and had expressed interest in continuing to work with me. They were considerably less energy intensive than the coffee-shop and roastery, which provided helpful variation in my sample. Furthermore, they were situated local to my home in London, which made the site very convenient. Finally, I also supported one of Hildebrand's existing sites, which included a small chain of shoe shops in London, where I helped to install and maintain GlowPro equipment to help Hildebrand. These were also reasonably local to my home and UCL, meaning they would also be convenient to work with as a backup plan if needed (but actually, this was not needed). The rationale for selecting three owner-managed businesses to study for this part of the PhD was based on balancing competing priorities of the level of depth of study I wanted to achieve with individual businesses, and the resources and time available to me to conduct the work. I took the view that more businesses would dictate shallower research with lower value results.

3.5.3.4 Inquiry cycles

Pragmatically, as the business owner-managers were based in different places, it was going to be difficult to have group discussions, so I reverted to doing in-depth interviews instead of group work which had been a significant part of part 1. I also knew that building on what I had learned from part 1 and previous research (Kenington et al., 2019) I was going to have to be flexible in the delivery of my approach, using a more 'Dionysian' approach than had been undertaken in part 1 ((Heron, 1996) pp 45), see section 3.5.2 (types of co-operative

inquiry). Taking a more emergent and spontaneous approach also aligned with my previous experience of working with retailers where it was necessary to be very flexible in order to engage with them effectively. For example, I knew I needed to physically go and see them at their place of work, and participate in discussions with them on-site. Furthermore, I knew that interviews would need to be undertaken very informally, likely whilst they often also went about their business of serving customers and undertaking other necessary activities whilst they talked to me when they could (Kenington et al., 2019).

Developing an Action inquiry proposal: As part of planning for part 2 I developed an inquiry proposal for each of the businesses I recruited into the study. I presented and discussed these with my participant researchers, encompassing this within the standard information sheet and ethics process as part of recruitment for the study (appendix section 4.2). I presented the approach to them in as informal a manner as possible, carefully balancing the need to mitigate any unnecessary pressure to participate with being accurate about their role(s) in the process alongside mine. Within this, I was keen to stress that whilst they knew that I was researching energy management and had a background in the subject area, one of the reasons why I was doing the research was to learn from them and so their participation in whatever form it took would be valuable and that I was there to learn from their expertise in running their businesses.

Approach to communication: As described in section 3.5.3.2, I saw communications as a clear priority, especially as I needed to recruit repeat participation with an audience known to have little time for and interest in energy. Therefore, I developed a communications approach by Torbert and Taylor (Torbert and Taylor, 2008) to plan the approach. This helped me focus on my intentions going into the project, including any underlying 'stakes', which I needed to identify and manage during the process. It also helped me to reflect on my AR practice. This is a model, which helps to plan AR practice and to capture this in words that aids later reflection. It describes four parts of speech necessary to support the change-oriented ethos of AR, framing; advocating; illustrating and inquiring. Further details of this approach is available in the appendix (Appendix 1.2)

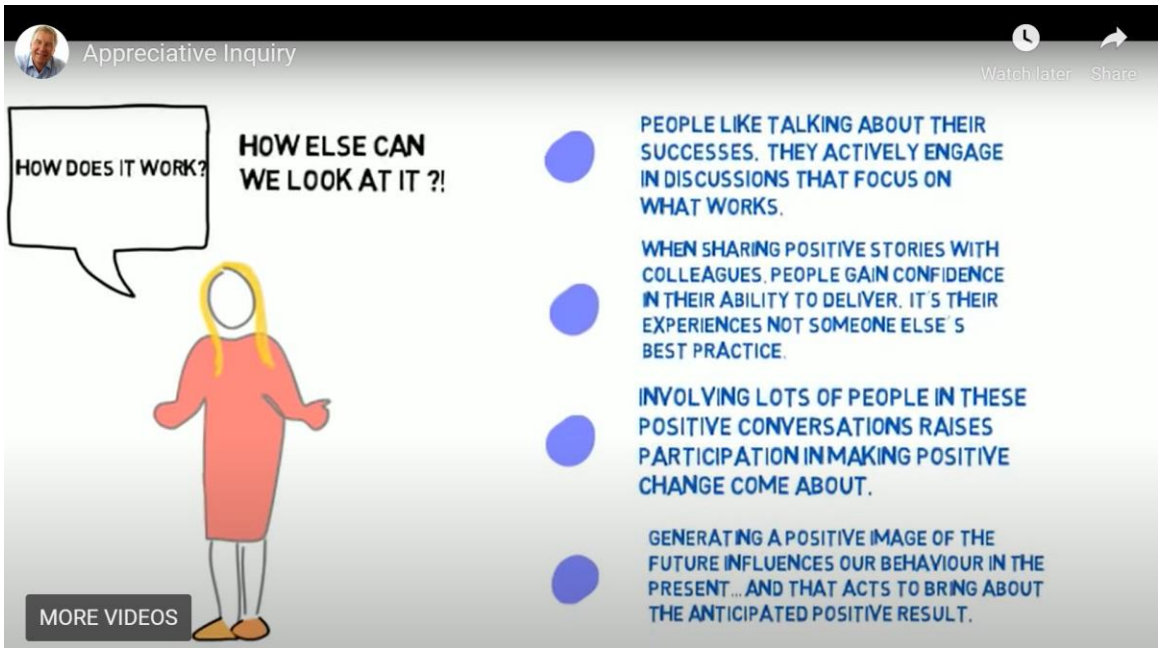
3.5.3.5 Interviews as part of a participatory research design

Interviews, whilst they are, in of themselves, not highly participative nor action focused, provide opportunities for developing these practices, particularly where the interview is

part of a longitudinal set of activities working with the same participants over time. I also used the interviews to develop rapport with the participants and explicitly designed discussions to be about them. I listened actively during delivery, too, to empower them by listening to their challenges and successes and relating them to the problem at hand, as opposed to the other way around. One element, which I noted as a theme early on in these discussions was that, alongside being labelled by others (Academia, Government) as hard to reach, I found that many felt themselves to be 'voiceless', and to varying degrees felt somewhat aggrieved and feeling like they were forgotten as a sector. Having noticed this within part 1, (and also previous research with retailers) I decided to use the principles of Appreciative Inquiry (AI) as a way to both understand how their operations worked, exploring this in a positive way, and also when exploring new ideas after introducing GlowPro and smart energy management data (Rothwell et al., 2016, Townsend et al., 2018).

Appreciative Inquiry (AI) is about 'searching for the best in people, their organisations and the strengths-filled, opportunity-rich world around them'. AI is not so much a shift in the methods and models of organizational change, but AI is a shift in the overall perspective taken throughout the entire change process to 'see' the wholeness of the human system and to "inquire" into that system's strengths, possibilities, and successes' (Rothwell et al., 2016). Given the context, and the change-oriented nature of this thesis, this approach felt appropriate to utilise, and it served well both in terms of eliciting insightful conversations. It also helped keep participants engaged and willing to spend time working with me. Some of the critical facets of the principles of appreciative inquiry are shown in Figure 26.

Figure 26: Features of appreciative inquiry (Townsin, 2013)



I found that they were generally happy to talk about their business and operations, successes (and challenges), and how they came about. This meant that they were generally happy to be part of the project once I had gotten over initial hurdles to engage with them in the first place. I was told by one participant (Josephine) that she saw herself as a willing accomplice and glad of the opportunity to be able to feed in, on the basis that the discussions might help influence Government and policy. She also felt that as a business, they might find elements of the discussions useful for their everyday operations along the way. Finally, this approach also facilitated the range of small-business research theories (entrepreneurialism; see section 2.7.6) which I was interested in contributing to in the context of energy management.

My role: I considered closely what my role should be within the Appreciative Inquiry. As described above, I designed my role to be first and foremost a listener and questioner, aligned with the traditional role of a qualitative researcher. However, to support the discussions' participative and change-oriented nature, I added two other roles into the mix.

Firstly, given I had a background in energy demand issues and solutions, I offered that I would be happy to discuss and explore with them any ideas or thoughts they might have about improving their energy management and use. I made it clear, though, that I would not foist this upon them and that it would be entirely up to them if they wanted this. Secondly; and more importantly, given I had spent time working with GlowPro and

understanding the data and how it had been approached in part 1, looking at possible broader applications of it within business operations, I took the role of exploring what other uses the data could have, outside of direct energy management.

Theory building: In line with having a more Dionysian, open and flexible approach and without the pragmatic need to directly inform the development of GlowPro, I decided that I did not need to have specific hypotheses to test within these cycles as we did for part 1. I was mainly interested in reflecting on what I was observing and experiencing within the approach and using qualitative data analysis and my reflections to inform theory. Within this context, I again used an inductive approach to theory building, particularly during the first cycle of inquiry, based on Grounded Theory (Glaser, 1967). This was employed iteratively and alongside the entrepreneurial framework based on Hauser et al. (2020), which I employed to a greater extent during the second cycle of inquiry in a more deductive approach to analysis.

3.5.3.6 Inquiry cycles

Figure 25 above shows the main activities associated with the two inquiry cycles undertaken in part 2. Below I describe the stages and activities I undertook in more detail.

Cycle 1: GlowPro installation, monitoring and testing

Cycle 1 involved the site-installation, monitoring and testing of the GlowPro prototype with the owner-managed SMEs. In the same vein as for part 1 (section 3.5.2), I describe each of the four stages of the inquiry cycles undertaken below (diagnosis, planning action, taking action, evaluating action/diagnosing subsequent cycles).

Diagnosis: Informed by the experience of part 1, I decided that I initially wanted to know more about the context of the businesses and understand their drivers and strategic approaches to managing their businesses, as well as how they managed energy. I also wanted to better understand their actual energy use, and here I now had the GlowPro prototype, which could be installed and used to monitor this.

Planning action: As described above, my initial discussions with the business owners and managers served the purpose of explaining the rationale for the project and what I was looking for in terms of their role and also their staff, and obtaining their agreement to take part in the project, explicitly as co-researchers. Within this, I introduced the broad concept

of the GlowPro system and sought their agreement to install the system to monitor their electricity consumption over time, complying with UCL research ethics and data protection requirements (appendix, section 0). I described that I would, later on, introduce them to the system and how it worked, but that it would be helpful for me to understand their electricity use before doing this and that this might be interesting for them as I could show them aspects of their use and work with them to relate this to what they did on-site.

Site visits: Next, I installed the GlowPro equipment on-site, using the clamp-based prototype Hildebrand had developed[49]. With the permission of the business owner-managers and engaged with the site staff to agree an appropriate time and access, I installed the GlowPro system on four sites (the SW coffee-shop, SW roastery and two cycle-shops within the cycle-shop chain). Informed by my previous research experience, I decided that my first visit to the sites should be fairly 'low key'. I wanted to not only install the equipment and not disturb anything upfront, whilst I wanted to monitor the sites, but also to gather an understanding about the sites and how they operated from observing what was there and how things worked on site. I was also keen not to draw unnecessary attention to the monitoring system, in case this might influence behaviours in some way before introducing them to it later. Notwithstanding this, I was prepared to discuss the system and any potential concerns they might have with monitoring equipment being installed as necessary. When I arrived, I had a short conversation with the site manager[50] to explain what I was doing, what the equipment was and what it did (to allay any concerns), and also give them my details in case they needed to get in touch with me for any reason. I then installed the equipment (a quick and easy process of installing current clamps onto the main electricity cable coming into the site). I then asked if I could take some photographs of the site, so I could get a good understanding of the layout and equipment on-site. I then had some short conversations with site managers to explain that I would be back in a few weeks to have a longer conversation with them when I would show them the system and ask them to participate in an interview.

[49] Only one of the sites recruited had a smart meter, and this was with British Gas, which was difficult to gain access to the data from a third party.

[50] Who in all cases had previously been told by the relevant owner-manager that I was coming (and in one case, the premises manager and the owner-manager were the same person).

Taking action: Following a period of monitoring electricity use, I returned to the sites to have discussions with the owner-managers, to get their impressions of the system and its capabilities. I took some printouts of the electricity monitoring data shown within the GlowPro system for these interviews. The topics covered in the interviews included:

1. Activities relating to energy use, such as the use of energy using equipment.
2. Initial reactions to the introduction of the GlowPro system.
3. Discussion about the data and how it related to on-site activities.
4. Any other perspectives of interest to participants based on the data and discussions.

At the end of the interview, I gave the participants access to the GlowPro system by sharing login details to each of the sites so that they could look at their monitoring data if they wanted to[51].

Cycle 2 – Further exploring smart meter and other data with owner-managers and other staff

Evaluation of cycle 1 and diagnosis: My initial plan had been to go back to the businesses after some time and do follow-up interviews to see whether and how they had used GlowPro, to help them manage their energy or sites. However, my impressions from the conversations when introducing them to GlowPro was that, in its current prototype form, they were unlikely to find it helpful or use it in a meaningful way. Given this, and my concern to ensure they did not feel obliged to do something they otherwise wouldn't do, I followed up with Josephine (coffee-shop and roastery owner-manager) about it. She confirmed my suspicions that it was unlikely that it would be used based on her understanding of the system. That said, she said it that this was not because there was not likely to be any use or interest in the data or system, it was mainly that in its current (semi-functional) set up, it was not going to be helpful for them. However, through further discussion, we identified that there were likely to be interesting uses for this type of data – if it were provided in different formats and/or within different operational management systems. Showing the smart meter data to them in the context of the GlowPro system had got her and her team thinking about other ways this type of information might be useful. She suggested that we embark together on some further follow-up discussions to explore

[51] This was possible either through a web portal or via an App installed on their smartphone.

how premises managers, in particular, manage their sites, and whether and how the data might be useful to inform and help some of their activities.

Planning action: I subsequently planned follow-up interviews with the owner-managers and premises managers across both the coffee-shop, roastery and cycle businesses, which explored in greater depth:

1. Their business motivations and goals.
2. How this translates into how they manage their operations and premises, including use of existing systems to manage operations and performance.
3. Introducing the smart meter data (using stimulus materials) and having broader discussions about whether and how this could be useful to them.

I took on board some initial ideas and suggestions Josephine had made and included these as prompts within the topic guides; however, I kept the discussions relatively unstructured so that the conversations could be flexible, depending on what was of interest. I also made it clear that whilst I was interested in energy, I was trying not to look at that explicitly and just get their thoughts and input based on how it might be useful for them, whether related to energy management or not.

Taking action: I then undertook these follow-up interviews with a combination of premises managers and owner-managers across all three businesses. The discussions also led to my identifying some other actors to also follow up with, which included a member of staff who had moved to another role, but who used to manage all the café premises and was very familiar with all of the stocking, point of sale and accounting management systems they, and many other café's used.

Evaluating action: As a final step, I came together with Josephine for a final discussion session to discuss some ideas and what this might mean. As discussed in the findings section (Chapter 5), this led to identifying other actors, which would have been useful to include within the discussion. However, my fieldwork at this point was interrupted by the COVID-19 pandemic, which in effect, ended my ability to conduct further fieldwork.

3.5.4 Secondary data

Being part of a Government funded innovation competition and working with a partner organisation meant that many documents were produced and shared with me. I collected

well over 100 documents in the course of data collection, which I included in my analysis. The types of documents included encompassed:

- Specifications and technical documents (e.g. Invitations and responses to tender);
- Policy documents;
- Progress reports (e.g. Hildebrand progress reports within the NDSEMIC competition);
- Research outputs (e.g. outputs from research carried out by Hildebrand and their consortium);
- Internally shared documents (e.g. through cloud-based document sharing systems, as Confluence[52]);
- System design drawings;
- Working documents, calculations, and spreadsheets;
- PowerPoint presentations;
- Website pages;
- Proposals and marketing materials
- Emails;
- Meeting notes.

Not all the documents were directly relevant to my study, so I developed criteria for selection purposes to include within the analysis informed by (appendix, section 1.1). The criteria were based on my research aims; the document's relevance to my research question and objectives and their usefulness in exploring energy management in an ND context. This reduced down the number of documents analysed.

The usefulness of documents varied according to its type (e.g. research report, contract etc.), the information it contains and its source (e.g. Government, commercial company). So, in addition to the selection criteria, in order to ensure I considered these issues and how they may influence inferences I took from them to inform my findings, I developed a further set of criteria, which I used to inform my analysis, based on the sources of documents and also, if based on research the methodologies utilised (e.g. qualitative and/or quantitative methods). Further details on the selection, source and methodological criteria are detailed in the appendix (Appendix section 1.1).

[52] https://www.atlassian.com/software/confluence

3.6 Analysis activities

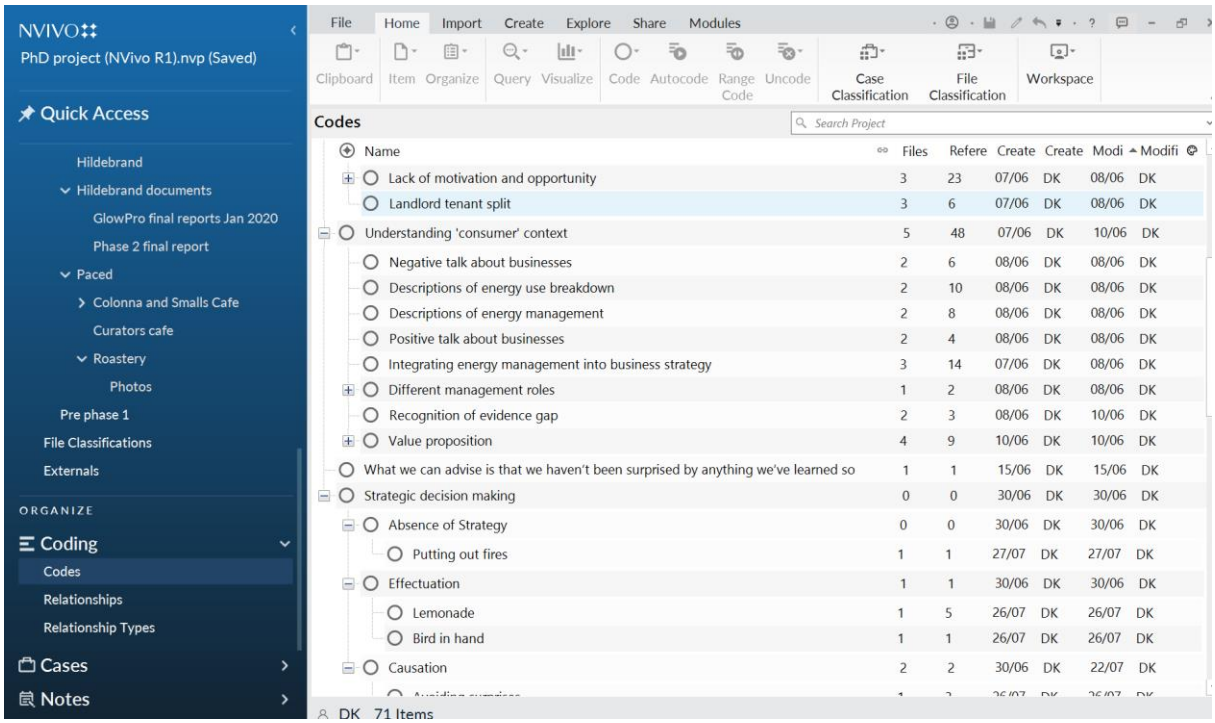
As described above, co-operative and appreciative inquiry involved cycles of action and reflection, where one stage influences the next. Reflecting this dual approach, I undertook two related types of analysis: (1) extensive and (2) intensive.

Extensive analysis: The first analysis I undertook occurred within the cycles themselves, whereby I aimed to continually aid the interpretation of the discussions, both within the groups and also resulting from in-depth interviews with individuals as the project progressed. This type of analysis was based on hypothesis testing which had been identified within the diagnosis stages of the co-operative inquiry cycles. I wrote copious notes during in-depth interviews, which I was not able to record in order to minimise missing any details through lack of recall later on, or potential researcher bias (Rutakumwa et al., 2020).

During the fieldwork, I undertook short analyses of the co-operative inquiry cycles. For example, I wrote summaries of the insights from the interviews undertaken in part 1, which I then shared and discussed with the group to inform what we collectively thought this meant for the hypotheses which had been identified. I subsequently recorded these discussions and analysed the groups' responses to reflect on what this meant for the next stages of the cycles. At this point, in most cases I did not have access to full transcripts (due to time constraints, and in some circumstances I was not able to record interviews as they were undertaken in public settings). As the purpose of many of the group meetings were to discuss what we thought we had learned, and how we thought we might use that for the next stage of the project, at the end of these meetings there was already a shared sense of this, which I wrote detailed notes of after the meetings had finished.

Intensive analysis: The second type of analysis was in-depth analysis across both stages (parts 1 and 2) of the research, including in-depth analysis of the context and process of the cycles in order to inform the outputs within this thesis. I utilised coding to capture as many aspects of cycles as possible in words, which could also be analysed through coding. In order to support this, I utilised qualitative analysis software NVIVO. NVIVO assists the coding process, and allows storage of coded data in a format that can be efficiently retrieved for various purposes including thesis writing. I used a similar coding structure for both stages of fieldwork (parts 1 and 2) of the thesis, although they evolved mainly due to the change in focus and group participants between them.

Figure 27: Coding structure overview in NVIVO



As described in detail above, during both research parts (1 and 2) I started out using Grounded Theory to inform an inductive analysis approach, building up a picture of what was happening from the data itself (Glaser, 1967, Martin and Turner, 1986). This led to the identification of the Hauser framework of Causation, Effectuation and Absence of Strategy (Hauser et al., 2020). As my fieldwork and subsequent analysis progressed, I used this framework to code and further analyse the data to inform the findings and conclusions described in the following chapters. The literature review describes the coding framework and structure used in detail (section 2.7.6).

3.7 Research practice

3.7.1 Confidentiality

The partnership with Hildebrand Technology Ltd was governed by a non-disclosure agreement (NDA), which I signed with them at the start of the project partnership. All information gathered whilst working with Hildebrand was treated as confidential unless it is already publicly available, or approved by the company.

The Hildebrand staff who worked with me were given the opportunity for themselves to be anonymised as part of reporting within the PhD thesis. On review of detailed thesis sections

they were involved in, they declared that they were happy to be named in an attributable format.

The owner-managed SMEs who participated in the second part of the PhD were asked whether they would like their views to be anonymised. Whilst none of them expressed explicit concerns with this, I chose to anonymise them. Firstly, whilst the risks are likely to be minimal, I believe anonymisation protects them from any potential harm arising from the views they provided. Secondly, business discussions about sustainability can be subject to concerns about 'greenwash' (Lyon and Montgomery, 2015), and so anonymising their views may lead to a more honest and open discussion around the topic area.

3.7.2 Data protection

During the PhD I collected personal data, which was not sensitive in nature. The PhD was registered with the UCL Data Protection Registration Service (reference No Z6364106/2019/01/06) and is compliant with the General Data Protection Regulation (GDPR). Data relating to the PhD, including personal data has been collected and stored in a secure manner in order to protect it from unauthorised access, disclosure or loss, as required by the Data Protection Act. This included secure storage of paper documents, removing files (including interview recordings, where these were used) from storage as soon as possible and password protected for electronic devices and applications, such as the analysis software used (NVIVO).

I also was given access to commercially sensitive information by Hildebrand, mainly via them providing me with access to shared company folders. I only downloaded documents from these sources, which I needed substantially to inform the PhD (and were done with the explicit knowledge of Hildebrand), and then these were stored in protected UCL servers.

3.7.3 Ethics

Ethical issues relating to social research often focuses on avoiding harm coming to vulnerable participants (Byrne, 2016). However, within management research, the relationships between the researcher and their participants are often quite different in nature. The researcher often has an established relationship, or partnership with the organisation they are researching, and participants are often, as was the case particularly with Hildebrand, knowledgeable about the subject area such that they often knew more

about an issue than I did, which changes the power balance in the relationship (Bell and Bryman, 2007). Furthermore, AR combines theory and practice (and researchers and practitioners) through change and reflection in an immediate problematic situation within a 'mutually acceptable ethical framework' (McKay and Marshall, 2001, Davison et al., 2022). Within this context, McKay and Marshall emphasise that the researcher is ethically bound to try to alleviate the problem (Avison et al., 1999). Across both management research and AR, broadly the implication for ethics is that informed consent, takes on a different meaning, whereby it is subject to continual negotiation and takes the form of a more reciprocal arrangement.

To ensure I approached the issue appropriately, I followed the guidance provided by Davison et al and Bell and Bryman in developing the approach to ethics. This meant in practice that, whilst I obtained informed consent agreements from all participants, I made it clear that ethics was something we should review from time to time during our interactions, and I encouraged participants to raise any issues as the project progressed.

This research was carried out with approval from the appropriate UCL ethics committee. These issues were discussed with the BSEER ethics committee during the process of registering with the UCL BSEER Research Ethics Committee and reflected in the approved ethics application. Please see the appendix (section 0) for details of information sheets and ethical approval.

4 Findings part 1 – developing the GlowPro prototype

4.1 Overview of chapters 4 and 5

The forthcoming two chapters describe the thesis findings. The findings are split into two, part 1 (this chapter) and part 2 (chapter 5). The findings are structured in this way because they have different focuses, as described in chapter 3. This chapter focuses on two AR cycles of inquiry that informed the GlowPro system's development and culminated in a testable prototype. Chapter 5 subsequently focuses on two further cycles of inquiry undertaken with three owner-managed SMEs, which involved testing of the prototype as well as exploring broader potential uses for smart meter and other data with the owners-managers and other staff. Both chapters broadly follow the structure of the inquiry cycles described in chapter 3, although they are more summative to facilitate a clear narrative. Each chapter commences with an introduction section, followed by a synthesized description of the analysis and finishes with a summary at the end to tie them together before moving into discussion and conclusions in chapter 6.

Finally, it is worth reminding the reader of two aspects of the method that feature in the findings because of the AR approach and may differ from findings chapters in other PhD theses. First, the findings are explorative and read like a 'voyage of discovery'. This is a common feature for AR projects, as to make sense of the findings, it helps to bring the reader along on parts of the journey. Second, the findings include sub-sections describing self-reflections (or critical reflections as described by Kemmis et al. (2015), see section 3.2.6). These include personal thoughts and observations focused explicitly on my role and agency within the project (and how this interfaced with broader concerns of my participant co-researchers[53]), considering how this influenced the project and, conversely, how the project influenced me.

4.2 Cycle 1 – informing GlowPro development with retail and hospitality businesses

As described above, the team further explored the roles and potential needs of core users of the GlowPro system, including retail/hospitality managers and shopping centre managers through a series of in-depth interviews. The interviews informed the system design, which is described further below. Hildebrand felt that, as I was a new team member, shadowing

[53] Which are called 'group concerns' within the analysis.

these interviews would be a useful introduction to the project, so these were the first substantive activities I undertook with them.

Group composition and dynamics: The core-group who came together for the discussion meetings was led by Jane Wilson, Hildebrand's Chief Operating Officer (COO) and overall Competition project manager. Jane was also my primary contact within Hildebrand and was the person I worked with the most and we developed a close working relationship over the Competition period and subsequently. As described in the method chapter, during busy periods of research and testing, we spoke at least weekly if not daily. Other team members included Josh Cooper, Hildebrand's CEO, who attended most of the discussion sessions and led on the technical development of GlowPro, supported by in-house analysts. Thomas[54], a customer experience strategist was also a core member of the team at this time. Thomas was an expert in designing digital services (e.g. smartphone Apps) for corporates, and he led the process of designing the research elements, including in-depth interviews with target users of GlowPro, and how this translated into different types of user interfaces within the GlowPro system (e.g. building managers, individual premises managers, shop-floor staff). Whilst the four of us comprised the central team, and focused on the design activities; other team members led other tasks. For example, two Hildebrand technical analysts undertook vital development and support tasks, such as developing the GlowPro architecture and deploying prototype systems, including monitoring kit installation for user testing. There were also other partners, including an organisation called Hopes Ltd which served the Hospitality industry and who led the testing and deployment of GlowPro with hospitality SMEs[55].

GlowPro system development process: Whilst I did not get directly involved with the development of the GlowPro software and associated hardware kit[56], the activities we undertook as a group directly informed its development so the process by which this occurred is described here. The approach focused on the customer's experience using the GlowPro solution. Customer experience is defined as the "*totality of cognitive, affective, sensory and behavioural consumer responses during all stages of the consumption process"*

[54] A pseudonym has been used to anonymise their involvement.
[55] Salford University, also played a role, building a technical building physics and modelling role on the team, but I did not get directly involved with this element of the project, so they do not feature in the findings.
[56] See Chapter 3, section 3.4.2, Figures 2 and 3 for an overview of the system.

(Bagdare and Jain, 2013, Schwager and Meyer, 2007). This definition underpinned the exploration undertaken in the interviews. Led by Thomas, the team used a customer experience design process called 5Ds, shown in Figure 28. This process started with insights from research activities in the early stages (Discover), which led to discussions and activities to design the system (Decide).

Figure 28: 5Ds process used to develop GlowPro[57]

Discover	Business strategy, desk research, product architecture, hypothesis, target audience, primary research, needs and goals
Decide	Requirements documentation, prioritisation, audience roles, MVP definition, service canvas, additional requirements gathering, data exchanges across platforms
Design	Functionality, information architecture, user interface patterns, visual design language, iteration
Deliver	Prototypes, user research, demonstrate data 'in situ' with context, specification, assets, build support, QA
Drive	Data analysis, conversion optimisation, behavioural change, roadmap development, service design

The decision process was managed by building a central 'user-requirements' spreadsheet, an excerpt of which is shown in Figure 29. The spreadsheet encapsulated all of the detailed potential activities and research questions. Within this, we used a design thinking approach called 'How Might We', which is commonly used in user experience design processes (Anderson, 2021). We used two discussion sessions to develop a range of HMW statements, which were then subjected to a SWOT analysis (Weihrich, 1982) and prioritised. The outputs of these activities were used to inform the further development of the GlowPro prototype developed by the Hildebrand technical team (Design, Deliver, Drive).

[57] MVP stands for 'minimum viable product', defined by the team as a version of a product (GlowPro) with just enough features to be usable by early customers who can then provide feedback for future product development. QA stands for Quality Assurance, defined as a systematic process of determining whether a product or service meets specified requirements.

Figure 29: Screenshot excerpt of the GlowPro user requirements spreadsheet

Hypothesis ID	Hypothesis	Phase for implementation - Assure	Phase for implementation - Reflect	Phase for implementation - React	Strengths	Weakness
1	That by providing options to tenants for community energy supply changes can be brought e.g. solar	Phase 1				
2	That weekly energy training can be provided at a team meeting		Phase 1	Phase 1		
3	Data from tenant to landlord can assist in the total efficiency at a centre	Phase 2				Changes to legal infrastructure (e.g., leases) will be needed to assist tenants and landlords in sharing data to enable both groups to monitor, measure, and report energy use
4	Show the potential saving for that given site: today vs. potential	Phase 1				
5	Show what can be done to these types of buildings, where meters are old: e.g. clamp	Phase 2				Does cultural and historical significance stop meters being fitted?
6	That landlords will permit installations of smart meters	Phase 2				
7	Leases specificying that meter installation is acceptable					
8	That a BMS output is integrated via service(s) and realtime	Future	Future			
9	That by providing a messaging interface there is less need for physical meetings to take place		Phase 1	Phase 1		Whitson and Crawford (2013)'s results suggesting that landlord and tenant communication is difficult to achieve
10	Selectable tips should be widely communicated	Phase 1	Phase 1	Phase 1		
11	That the general public being made aware of the energy cost of using the lift and the health benefit of walking up stairs iin Shopping Centres would reduce operation (e.g walk 5000 steps in here today)	Phase 2				
12	Hook - facilitating experts with data (through sharing) to enable them to make impact estimations accurately	Phase 1			Estimations of financial savings from an independent source	
13	Hook - showing wastage (fridge door open)		Phase 2	Phase 2	"Waste not, want not" – reducing unnecessary usage	
14	Hook - showing neighbours or similar stores	Phase 1	Phase 1	Phase 1	Social norms – what other people are doing and saving	
15	Hook - showing heat waste (property model)		Phase 2	Phase 2	Images can also be an effective hook e.g. thermal images	
16	Information For energy managers provide answers to wizzard		Phase 2			
17	Providing who to go information: tailored to each business		Phase 2			
18	Showing energy consumption history (was IHD, now GlowPro) as applies to strategy recommendations		Phase 2		Evidence Linking energy advice to the energy consumption history (was IHD, now GlowPro)	
19	Showing an isolated appiiance in GlowPro is a key hook	Phase 2	Phase 2			
20	Provide hard copy materials (digital) content			Phase 1		Break common assumptions about energy usage with 'myth busting' sections
21	Start dialogue - make it personalised		Phase 2			

4.2.1 Initial reflections – opportunities and concerns

As described above, in keeping with the AR approach, this sub-section describes relevant initial self-reflections and broader group reflections discussed by the team.

Personal reflections: Regarding the system hypotheses (Figure 30[58]), the team's focus on energy management *inattention* was intriguing (hypothesis one); it appeared that it was implicitly obvious to the team that it was the crux of the issue. In the literature, this was described as an important issue, but it appeared as part of a range of other challenges. It did not feature prominently as the most important one (Chapter 2, section 2.5) (Economidou and Bertoldi, 2015, Revell and Blackburn, 2007, Lunt et al., 2014).

Hypothesis two, related to catering for different energy management needs according to a range of actors, has been reflected in the literature and seemed particularly relevant within

[58] Also shown previously (Figure 24) but replicated here for convenience.

the shopping centre context (Bull and Janda, 2017, DeCanio, 1993). The activities involved with the detailed GlowPro system design process described above were new and unfamiliar to me, so involved learning on the job as we went. Such activities had also not been described in the literature (Chapter 2, section 2.3.5), so it was interesting to experience and contribute to the design process. The process involved exploring not just energy management but a much broader range of operational activities, including (e.g. cleaning processes and security procedures) undertaken by actors who potentially could have an interest or role in GlowPro (such as premises managers, shop floor staff and building managers). It also was detailed and rigorous, with the team exploring precise details of operational processes and challenges they faced in undertaking day-to-day tasks.

As described earlier, I had an over-arching concern regarding hypothesis three as shopping centres, as large multi-tenanted sites have been described as an area where energy management is more challenging due to the presence of complex organisational layers (e.g. landlords and tenants with both local and off-site head office interests), each with different involvement and interests in energy management (Janda et al., 2015, Goulden and Spence, 2015). This made it seem like a more challenging target than others Hildebrand could have picked. Furthermore, shopping centres seemed at odds with the goals of the NDSEMIC Competition as they cater more for large-chains than SMEs.

Figure 30: GlowPro hypotheses for research testing

Three hypotheses:

1. Retailers and hospitality businesses are not interested enough to fund/use a system which only serves energy management. The system needs to provide other benefits too in order to be viable.
2. The system needs to be designed to cater for very different needs according to the different organisation structures and roles and responsibilities of the users.
3. Shopping centre managers are a good target for implementing GlowPro in shopping centres.

Group reflections: The main substantive concern the team were focused on was how to develop GlowPro in such a way that they could overcome the attention-deficit problem

concerning energy management (hypothesis one) (Revell and Blackburn, 2007, Trianni and Cagno, 2012), which they had experienced first-hand already. Their focus here was on broadening the scope of GlowPro to make it more useful, which is discussed further below.

Our initial research confirmed that the real challenge was one of engagement – businesses simply have neither the time or the inclination to make changes and energy is not expensive enough for them to care… A strategic approach was required to create an experience that was so useful to the business that BEIS' ultimate goal of demand reduction could be delivered (Hildebrand Phase 1 BEIS report).

4.2.2 GlowPro user interviews

There were two strands to the user interviews, first; interviews with shopping centre management staff to inform the development of GlowPro within this context (section 4.2.2.1) and second; interviews with SME hospitality and retail businesses owner and premises managers (section 4.2.2.2).

4.2.2.1 Shopping Centre findings

Investigating the development of GlowPro within a shopping centre context involved interviews with staff from two large (>35,000m^2) shopping centres. The centres were self-described by their shopping centre managers (SCMs) as 'second-tier' as they were located in suburban hubs in the outskirts of London and catered to generally cash-constrained local and commuter customer audiences. Both centres were over 30 years old, with occupiers comprising mainly large retail and hospitality chains. Shopping centre managers (SCMs) were employed by portfolio owners who were publicly listed Real Estate Investment Trusts (REITs[59]) in both cases. Their role was to lead the local operation and management of shopping centres. A critical aspect of their role was to manage relationships with occupiers and their parent companies and ensure the good maintenance of facilities and common parts. They also played a local marketing role, organising activities and events within the shared spaces designed to help attract shoppers to the centre. Energy and its management

[59] A real estate investment trust (REIT) is a company that owns, operates, or finances income-generating real estate. REITs pool the capital of numerous investors. This makes it possible for individual investors to earn dividends from real estate investments without having to buy, manage, or finance any properties themselves.

operated within a complex ecosystem similar to that described by Axon et al. (2012) (Figure 31).

Figure 31: Schematic diagram representing complicated energy flows and uses in a hypothetical shopping mall (Axon et al., 2012)

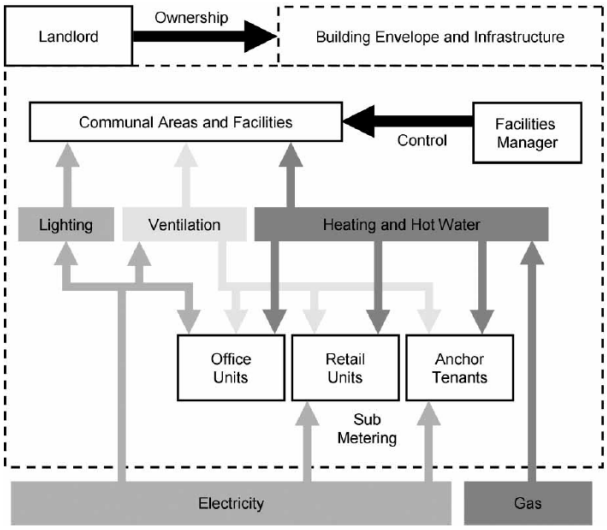


Figure 4 Schematic diagram representing the complicated energy flows and uses in the hypothetical shopping mall described in Box 1. The split pathways illustrate the difficulty in apportioning costs relating to implementing energy-efficiency measures or distributed/ renewable generation in a tenanted commercial building. The electricity potentially is supplied by three different retailers

The SCM team contracted and negotiated energy supply for each shopping centre, either directly themselves or working with their respective head offices, enabling scale by aggregating energy use across multiple shopping centres. Subsequently, SCMs were responsible for sub-metering each tenanted unit within the shopping centre for billing purposes. They also recharged, usually on a proportionate per square foot basis, individual contributions to the energy use of common parts, including lifts, centralised lighting, and heating and cooling systems (HVAC).

Costs were negotiated within the overall negotiation of service charges, which SCMs managed annually with occupants. As relatively old shopping centres, their metering infrastructures were described as antiquated, with several idiosyncrasies. These emanated from recent or historical refurbishments, which had updated or changed aspects of the shopping centre. This meant that within the same system, different types of meters were present, including old ones that needed to be read manually and different types of newer

Advanced Meter Reading (AMR) devices[60]. These factors together made meter and bill management a challenge for the team. Also evident was the presence of split incentives, which had implications for how energy was managed on-site. For example, whilst occupants communally paid for the energy demand for the common parts, energy demand relating to individual shops was usually managed separately, and often in the case of large retail chains, by an off-site central head office team, meaning that opportunities for managing demand at the premises level was done elsewhere.

The SCM contracted overall facilities management contractors, who were responsible for ongoing maintenance to ensure the smooth running of the centres. They worked on-site and closely with the SCM team even though they worked for separate organisations. When refurbishment work was needed, this was negotiated and paid for via the annual service charge contracts and sometimes involved sub-contracted energy consultancies[61] in specifying upgrades or changes to energy-using equipment (e.g. HVAC systems) or building fabric.

Interest in the concept of GlowPro from an energy management perspective was based on its potential ability to help automate the metering and billing process, which would save SCMs and tenants money and time. However, they also described that the energy element of the overall service charges for occupants was proportionately very small, which meant that it would be hard to justify investing in the system, as all shopping centre investments had to be recharged through service charges. This would be not easy to justify in the challenging climate for shopping centres if it only served energy management needs, without other benefits.

"*Energy is the smallest part of the bill, so our tenants might not care about that specific element*" (SCM1)

SCM1 described that it was tough to do anything proactive regarding energy management because tenants spent significant time and effort each year negotiating the service charges and getting them down to the lowest possible cost. She described that several of the

[60] An AMR communicates automatically from the site to an energy supplier, or an intermediary of the supplier at regular intervals. It is different to a smart meter as defined by the GB smart meter roll-out.
[61] Either working directly for the owner REIT, or sub-contracted by the facilities management company.

national retail chains contracted out service charge negotiations to professional negotiators who were performance paid based on how much costs they could negotiate down. This disempowered SCM's abilities to do proactive activities on-site as they would not get funding for them unless there was a very compelling business case.

Alongside interviewing the SCMs, Hildebrand tried to interview some tenant occupier representatives within the shopping centres but found it difficult because many of them were unable or unwilling to participate in research without permission from their head offices. Despite Hildebrand making several approaches to the head offices, their teams were hard to engage, and when a response was received, they did not want to participate.

"*There is a lack of* [tenant occupier] *participants – from area managers to store managers willing to engage*" (Hildebrand, BEIS report)

Before I joined the team, Hildebrand had employed a' guerrilla-research' approach to help gather some understanding about occupiers locally (Caldwell et al., 2015) by venturing into some of the shops and asking a few simple questions of store staff when they were not busy. Jane described that the staff tended to be young, poorly paid, and often worked long hours and because of this, they felt little loyalty for their employers. When this was raised with the SCMs, they described that this was broadly true and that the shops often had high staff turnover and constantly needed to recruit new staff. Staff were often unhappy with their employers, which meant that they were reluctant to go out of their way to support them beyond their contractual obligations, which was apparent when discussing energy management at the premises level. Jane described that staff had told her that whilst they were energy-conscious and had concerns about climate change personally, this was less reflected at work. One pointed out that they would not get any personal benefit from reducing energy use as they would at home and that, given their often fractious relationship with their employer, they might even purposefully leave equipment on to spite them. However, if some incentives were involved, they might act differently. Overall, this identified that due to the multitude of actors and the complexities of different interests, the GlowPro tool had to overcome some significant challenges to be useful. There did not appear to be an actor with an over-arching interest or agency in energy, and each different actor appeared to engage in energy management infrequently.

"*There are a large volume of* [energy-related] *tasks which have low-frequency*" (Hildebrand, BEIS report)

During interviews with SCMs, the team took a very open and broad exploratory approach, discussing both energy and non-energy management aspects of staff roles. This helped to identify two potential opportunity areas for GlowPro, one specifically energy-management related and the other which ventured into non-energy management operational issues. These are described in further detail below.

SCMs facilitating local premises level energy-management: One of the SCMs described that whilst store staff often did not have a good relationship with their head office employers, they usually had a much better relationship with them as the local SCM team. As described above, a large proportion of the SCM's role was to be local relationship managers. This means they spent considerable time each week 'walking the floor', speaking to store staff, discussing any issues with their premises, operational issues as well as strategies and activities which would be done at a centre level (e.g. market stall events, or live music in the shared spaces) to increase footfall, thereby helping the stores meet sales targets. Because of this, they knew the stores and their staff very well, and they communicated with them informally on a day-to-day basis and at regular monthly meetings held by the management team. Because of this, the SCM felt they might be a better source of advice and guidance on energy matters in communicating with staff. Firstly, they felt they often had better and more regular communication with store staff and a more trusted relationship with them and this could be a service that they could provide to help them all save costs. Secondly, they could use a system like GlowPro as a way to develop some sort of competition between stores, either via developing an 'energy league table', or providing some sort of incentive (e.g. free pizza or tablet of fizzy-pop drinks) for stores that lowered their energy consumption by a target amount as a fun local competition between stores.

GlowPro as a potential communications system and security aid: One of the main challenges all of the SCMs described in their broader day-to-day operations was communicating with each store effectively. This was primarily because existing communications systems (usually a radio system) were old and did not function well. Although specific staff were provided with either radio or a communications telephone, they often did not use them because of high staff turnover or staff forgetting to have them

with them when they were at work. During the interviews, they discussed that having a fixed display in each store that could be used as a communications system would be very helpful. These could be put by the till and whoever was there would see messages from the SCM team. This primarily would benefit them by communicating urgent security issues, such as identification of a shop-lifter or security alert that could be sent out to all the shops immediately. One SCM described that they had real problems communicating security issues, which cost their tenant stores thousands yearly due to shoplifting. The SCM described that whilst it would be hard to justify the costs of GlowPro purely from an energy management perspective, this additional functionality would enable them to justify and potentially pay for the system out of their security budgets. Whilst this was not particularly relevant from an energy management perspective, it was decided that this might be an additional use case for GlowPro, which was worth investigating further.

The following sub-section summarises insights from exploring GlowPro potential with owner-managed SME retail and hospitality businesses.

4.2.2.2 Owner-managed hospitality business findings

Compared to shopping centres, the energy management eco-system within owner-managed hospitality businesses appeared less complex. There were fewer actors involved, principally being limited to an occupier and the landlord, and here energy management and billing was in all cases, the sole responsibility of the occupier.

One set of interviews was conducted with the owner-manager of a small independent chain of bars and restaurants operating in central London. They were interested in the concept of GlowPro because their energy bills were high, and they experienced 'bill-shock' from time to time, as meters would not be read for long periods, which could lead to large discrepancies between estimated and actual consumption (Shovelin, 2022).

From a billing perspective, these interviews also helped identify the presence and activities of Third-Party Intermediaries (TPIs), who acted as middle-men for small business energy supply contracts, energy management and consulting services, for example, when energy-using equipment needed maintenance or upgrading (Ofgem and Citizens Advice, 2015).

Exploring operational activities and challenges revealed several potential uses for GlowPro from an operational management perspective. The owner-manager asked whether it would

be possible for the system to alert you when there was a power cut or some other unusual energy use activities to alert them to on-site issues.

"*We have thousands of pounds of produce in the freezers [e.g. Lobsters and steaks], which we could lose if there is a power-cut overnight when nobody is on-site. This has happened before, so we would be very keen to explore alerts to tell us this*" (Owner-manager, London restaurant and bar).

The interviews also identified some other areas of interest in the system. Firstly, when describing what outputs the system would be able to show, including real-time electricity use, this resulted in questions about how to disaggregate this to understand the energy use of individual equipment items or types, such as lighting and refrigeration. This would unlikely be possible within the development of the GlowPro prototype within the Competition itself, but Hildebrand was interested in exploring this potential further.

In addition to the interviews I participated in, Hildebrand had, through other interviews, explored the potential for GlowPro to monitor internal temperatures as a way to help manage the internal environment better, on the basis that some interviewees struggled with their premises becoming too hot or cold at different times of the day, varying by season. Furthermore, they had also identified a possible health and safety benefit, if they could also monitor refrigerator temperatures. This was something which needed doing twice per day to meet food safety standards, for which the Local Authority could inspect them at any time (and would incur significant penalties if they could not show up-to-date monitoring) (Food Standards Agency, 2007).

4.2.3 Reflections

Personal reflections: Exploring the roles and activities of different actors within both the shopping centre and owner-managed SME contexts had help show first-hand prevalent energy management issues, challenges, and opportunities relevant for the development of GlowPro. The focus on hypothesis one (energy-management inattention, Figure 30) and how to improve this appeared helpful, and including both energy and other operational issues within the research had been useful to identify potential opportunities for GlowPro's development into a tool, which had greater chance of being useful for individual actors.

Given the complexities of the shopping-centre context, I had anticipated that the team would have evolved their priorities to focus more on smaller businesses in less complex premises (E.g. high street locations) because of the apparent greater simplicity of the context and interest in energy management from owner-managers, but this did not happen. Instead, the team responded by wanting to explore further the activities of additional actors in the shopping centre context that we had identified, which included non-energy management (security system functionality) and the activities of energy consultants. Whilst I could see that this would help improve the utility of GlowPro within the shopping-centre context, they deviated from the energy management brief and the goals of the NDSEMIC Competition, which was confusing. I raised this issue with Jane during one of our informal catch-ups, to get a sense of why they were less interested in individual SMEs. She described that they understood the potential conflict, but as a small business themselves, it would be very difficult for them to target SMEs directly as they viewed them as too disparate and hard to target; the marketing costs would be enormous without going through larger intermediaries. That said, the team were interested in some aspects of targeting individual SMEs. Firstly, as described above, the concept of disaggregating energy use to different equipment or uses was clearly interesting to the team. Secondly, they were very interested in the activities of TPIs, which they wanted to explore further. Both these areas are discussed further below in sections (4.3.5 and 4.3.3, respectively).

Finally, reflecting on the overall experience of doing interviews with the team, their approach to doing interviews was markedly different from how I had done them previously[62]. A team of several people attended the interviews, often with different team members, depending on who was around and available at any time. The experience of doing them was also somewhat noisy and chaotic, partly because we were often in a hospitality environment (e.g. sitting at a restaurant table whilst staff were busily preparing for the lunchtime service[63]), but also because several people talked concurrently, including various side-conversations. I was also surprised at the broad focus of the discussions. They mainly focused on understanding what participants did on a day-to-day basis and what issues they had with them. Only on a few occasions did energy and energy management get

[62] Which had been usually as part of a consultancy project and thereby generally following a relatively formal approach.
[63] As in the case of the London hospitality owner/manager interview.

explicitly discussed, and even when it was, I was surprised at the lack of attention it was given by both Hildebrand and the interview participants.

4.2.4 Updates to GlowPro / further hypotheses to test

The interviews culminated in group discussions to inform the further development of GlowPro. Given the complexities of the SCM ecosystem, I introduced the middle-out perspective (MOP) concept as a way of conceptualising the different actors involved and their different potential interests and influences on energy management (Janda and Parag, 2013, Parag and Janda, 2014), which the team embraced. The team found this term helpful in focusing on the (various) roles that groups who were neither top (e.g., policymakers) nor bottom actors (e.g., consumers) play in the shopping centre energy ecosystem. The MOP resulted in thinking about actors operating on the central shopping centre management on the one side and the retail/hospitality occupants on the other, discussing their different roles with respect to energy and broader operations, shown in Figure 32. The discussions also directly informed the next developments of the system shown in Figure 33, which included a new hypothesis relating to middle-actors, to be explored in the following inquiry cycle.

Figure 32: Updated potential GlowPro user roles; shopping centres and retail/hospitality ecosystems

Figure 33: Overview of GlowPro system developments

GlowPro developments across staff roles			
Assure (Property/portfolio managers)	Reflect (Premises/ area managers)	React (Front-of-house staff)	Connect (Monitoring kit installers)
Identified potential roles for additional actors within the shopping centre environment. **New hypothesis**: ***The system may be able to support the activities of other middle-actors, including facilities managers, energy consultants and others, such as security contractors*.**	System alerts highlighting unusual activities (e.g. power cuts). Potential non-energy management functionality. E.g. communications, between stores, between stores and support staff (e.g. security contractors)	Potential development of in-store display to support operational management and communications. Potential operational management role for the system – e.g. temperature logging (refrigerator, premises temperatures).	App development to support installation and post-installation performance checking.

We agreed to do a further round of research with middle-actors to explore 1) security and maintenance to understand the potential for GlowPro to support security operations and 2) energy consultants and facilities management to better understand their role and potential to influence energy management within the shopping centre context.

4.3 Cycle 2 - informing GlowPro development with middle-actors

As described above, this sub-section covers middle-actor interviews, including security/maintenance contractors, energy consultants and third-party intermediaries (TPIs). It also includes reflections and final updates to inform the development of the GlowPro prototype, which goes on to be tested later in Chapter 5.

4.3.1 Security contractors

Exploring security communications within a shopping centre context with security contractors confirmed that this was often a significant operational challenge. The lack of use or poor functioning of existing radio-based systems caused problems communicating when there were security alerts. An improved communication system was perceived to be helpful in supporting incident prevention and communicating alerts. This was because frequently someone within the site would observe a potential issue, such as a suspicious person, but be far away from them (e.g. in a security office on the other side of the centre), and they struggled to communicate with nearby stores quickly so they could intervene before an incident occurred.

The idea of having a fixed display in each store (as part of the GlowPro system) that could be used as a communications system, could be beneficial. These could be put by the till and so whoever was there would immediately see any messages from the security team, enabling them to act proactively, increasing the potential to avert problems before they occurred.

"*Adding a security feature (to warn others of a potential security risk) will make the other elements of GlowPro more attractive to potential buyers*" (Hildebrand Phase 2 report)

None of the security managers we interviewed had much interest in energy use, as this was not a direct concern of theirs. However, it was revealed that they did work with facilities and shopping centre managers to support energy management on a day-to-day basis. It was described that much of the buildings' functionality was controlled by Building Management Systems (BMS), but the security teams were often the frontline team who would do things for the estates team manually when needed. This included things like turning off lights, and shutting down non-essential equipment (e.g. printing machines, coffee machines etc). One of the facilities managers described that they kept the contact numbers of all security staff on hand to deal with any urgent issues which might arise with

the building, particularly out of hours. They also mentioned that communication with security staff was sometimes challenging (e.g. they were hard to get hold of at times and/or communications could be difficult). This meant that they would only get in touch if an urgent or essential issue arose (e.g. a power cut, or a system shut down).

"An e*asy to use interface makes it more likely that on the ground security staff will flag energy related issues*" (Hildebrand phase 2 report)

4.3.2 Energy consultancy support for smaller sites

The context for interviewing energy consultants was primarily to try and understand their role, if any, in supporting SMEs. The team wanted to identify whether there might be an existing energy consultancy market for SMEs that GlowPro might support. Secondly, Hildebrand also wished to understand what they currently did to support larger clients like retail and shopping centres to see whether and if so how GlowPro could potentially support their work there. Energy consultants' views on providing support for smaller organisations was broadly that it was not cost-effective or worthwhile. One interview participant described the market as being very price competitive and estimated that below an approximate floor area threshold of approximately 100m^2 it was not cost-effective to gather contextual information and business-related information needed to provide value-added services to clients.

"*It costs a few* [£] *hundred to send someone out, with a small-margins market like this, for smaller sites that immediately changes a three year payback calculation to a seven year one, which is then not going to happen*" (Energy Consultant 1).

Notwithstanding this limitation, the team were interested in exploring the idea of using aggregated smart meter data within GlowPro to help overcome the scale issue described by energy consultants and to explore the idea of creating larger markets for energy consultants by enabling the aggregation of multiple sites. One consultant described that collecting contextual information is vital to providing an effective service, and this is what was crucial for enabling them to provide effective client services, and that it was minimal what you could do with solely meter point data. This limited the potential of GlowPro to help, as it was unlikely to play much role in supporting the collection and analysis of contextual valuable information for energy consultants.

"*For SMEs I cannot see where smart meter data adds much value over AMR[64] data from an energy management perspective – maybe in small factories with specific processing issues I can see it, but for me submetering is much more useful*" (Energy Consultant 1).

Three of the consultants described that they spent much of their time and effort in larger organisations sub-metering specific equipment (e.g. refrigeration, lighting etc.). This was much more helpful from a management perspective, as you could use the data to identify what was using energy, when and in doing so, more easily identify opportunities for efficiency savings or if there were equipment faults.

Regarding the need for contextual information described above, Hildebrand were also interested in the idea of what GlowPro could be used as a platform to obtain 'user-derived' contextual data, which might be helpful for energy consultants to help them analyse their data. For example, this could include adding simple site survey questions within the system, which managers could fill out. This would not only support potential consultant activities, but it could also support better advice and information provision to help users improve energy management.

"How might we capture learnings specific to site which impact energy consumption that can't be determined from data alone (e.g. front doors always kept open to encourage footfall). (Hildebrand)

This was considered a potential use by energy consultants, however they challenged the usefulness of this, as users were not experts and therefore they were likely to miss giving them important contextual information which an energy consultant would pick up, for example on a site visit.

4.3.3 Non-domestic sector energy brokers / Third Party Intermediaries (TPIs)

Having identified TPIs within the non-domestic energy supply market (section 4.2.2.2), Hildebrand further discussed this with their existing energy supplier contacts. From this it

[64] In this context, Hildebrand were keen to understand whether smart meter data, available through their system which was able to be provided almost in 'real-time' could be useful for customers for either operational or energy management purposes. AMR data in the context of this discussion meant a meter, which provides data in the period 24 hours after consumption.

became apparent that there is a large energy broker market for SMEs, which accounts for a large proportion of energy supply deals in this sector (Ofgem, 2021).

"*Energy procurement in this market* [SME retail & hospitality] *seems broken; TPI's make the margin, offer no service, and then customers have to pay to access their own data: can GlowPro make the market fairer?*" (Hildebrand phase 2 report)

Initially, Hildebrand were interested to understand whether GlowPro could support the TPI market. However, they quickly formed the impression that the TPI market did not work very well for energy customers. The TPI market appeared to be primarily based on outreach targeting of SMEs to sign them up proactively to good market energy supply deals, which they claimed to be able to negotiate with suppliers as they worked as an aggregator. They secured business by taking the problem of finding the best deal away from individual businesses, based on the complexities of the market, and doing this on their behalf for many businesses, thereby finding them the best deals available at a larger scale (aggregation). In this context, there did not appear to be much explicit connection made between the business's contracted price and the actual energy used (or price per kWh). In this scenario, it became apparent that there was unlikely to be much role for a system like GlowPro, and in fact a system which enabled customers to see their actual energy use data might be disruptive to the TPI business model. This was interesting to the Hildebrand team as a potential business opportunity. They were concerned that many businesses could be paying over the odds for their energy and that they might be able to use smart meter data to disrupt the TPI market. Hildebrand were interested in the idea that through having become a DCC registered 'other user'[65], any ND customers who had SMETS2 smart meters could give them permission to access their historical use data. This could be used to analyse their use and help find them better deals on their energy tariffs. They wanted to explore the possibilities that GlowPro could also be used alongside the development of an energy tariff comparison site, which utilised this historical data to obtain better tariff deals, including time-of-use (TOU) tariffs. They also considered identifying potential 'collective buying' possibilities, which could be enabled through the aggregation of multiple users of GlowPro. This could provide an alternative to the TPI model, whereby SMEs could search for tariff

[65] https://www.smartdcc.co.uk/our-smart-network/dcc-customers/

deals through their comparison site, in a similar way to how this occurs in the domestic market, through sites like Moneysavingexpert and Uswitch. Whilst this was very interesting for the team, it was clear that tariff development was not within the NDSEMIC Competition's scope. However, these opportunities were developed further through other activities described in section 4.3.5.

4.3.4 Reflections

This second inquiry-cycle and developments to the system had been very interesting, and I had experienced many things I had not expected at the outset. During the interviews between Hildebrand and myself, there had been times when I struggled to understand their relative lack of interest in, and focus on, energy management. When talking to participants, energy management was subsumed within much broader discussions about participants' roles in operations and other areas. Even when it was discussed, it appeared almost covertly, to the extent that participants could almost miss it altogether, and I worried we were missing potential obvious energy-related management opportunities.

Hildebrand's rationale for focusing on broader issues than just energy management related to hypothesis one, whereby, they believed that it was not going to be possible to develop a successful tool without exploring other uses for GlowPro (particularly within shopping centres). By using the opportunity to focus on the broader potential of GlowPro as a communication and operational management system, I recognised that a range of new opportunities to develop a helpful system had appeared. Perhaps in that context, energy management could be improved as a co-benefit over and above providing other useful benefits, as opposed to energy being the main focus. Some of the explored opportunities had ended up being dead-ends (e.g. energy consultancy support[66]), but that did not seem to bother the team. To them, they seemed satisfied that they had followed up on potential avenues and been able to cross these things off and turn their attention to other opportunities when this happened.

From a methods perspective, what appeared important to Hildebrand was to fully immerse themselves in their participants' shoes, exploring issues entirely from their perspective. I

[66] Albeit, Hildebrand did not explicitly consider these as total dead-ends per-se as one of the energy consultants came back to further discuss with the team separately how Hildebrand might be able to provide services, which would add value to their customer propositions.

recalled noting in the research that informed the NDSEMIC Competition (Department for Business Energy and Industrial Strategy, 2017b) that energy experts lack of understanding of what SMEs did was a barrier to progress. So, it was interesting that this approach had discovered a range of interesting potential developments by focusing on what potential users were doing and trying to solve 'their' problems. This appeared to be a useful product of not explicitly exploring 'energy management' within the interviews, and this was something I learned for the following stages of research.

Finally, Hildebrand also seemed to have an innate understanding of what ideas and opportunities were worth pursuing and what were not, which I had been struggling to understand. I had noticed that they were very keen to explore opportunities which involved other partners, particularly more prominent players who could potentially provide resources or ways to access opportunities or markets that they, as a small business, would struggle to do on their own.

One of the things I found most intriguing was that while, as a team, we worked to a specified plan (according to the BEIS Competition), a range of other potential opportunities had come up during this time, which particularly Josh and Jane had leveraged to go and explore the system with people who, at the start were not intended as potential audiences (such as the TPIs). This seemed to be very entrepreneurial, whereby they would investigate and considerably 'flex' the potential offering they might develop (whether in the form of GlowPro or otherwise) depending on the type of opportunity they were considering. They then worked from potential 'hooks' they had identified through discussions with potential partners to work up potential systems or solutions which would cater to those audiences. Whilst it might be natural to expect a commercial organisation to behave like this, it was interesting to see it working up close and in practice. The direct energy management elements of the system took a back seat during these explorations unless it appeared to form part of the proposition naturally. Having seen how this occurred in practice, through the explorations with security contractors, TPIs and others, I felt I was beginning to see some method in what, at first had appeared to be, their madness.

Finally, there were still several areas I did not feel I understood very well, and they also appeared to be directly related to the very entrepreneurial way in which Hildebrand operated. This is where the link to entrepreneurialism and small business management

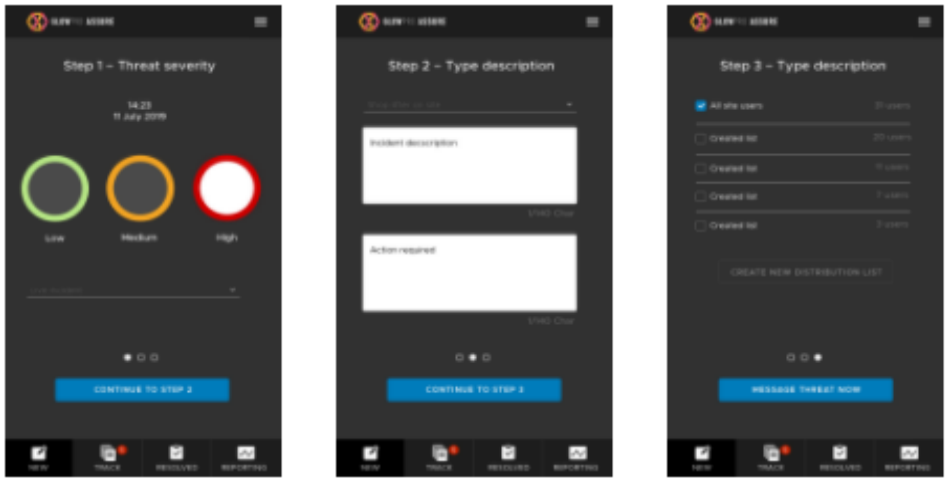
research (literature review section 2.7) came from. I believed that understanding more about entrepreneurialism would help me better understand how Hildebrand themselves operated. Section 4.4 explores their activities from the perspective of the theory of SME entrepreneurialism.

4.3.5 Final updates to GlowPro and Competition outcomes

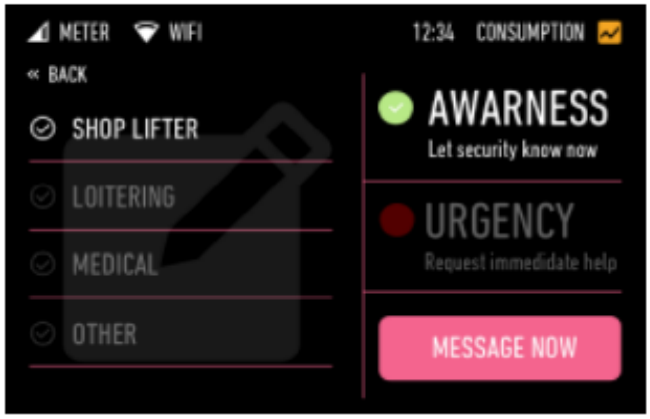
Following this round of interviews, we discussed next steps and updates to GlowPro prior to testing. The discussion focused on two areas; first, what further developments of the concept were useful, and second; what pragmatic developments were needed to have a good working prototype that could be tested within the next phase of the Competition.

The team could see the most promising GlowPro developments related to security communications; on the basis that SCMs had said that this would be the 'ticket upon which they could sell the system to their tenants'. Because of that, the team mocked up a series of screenshots that could be used for testing the system. These were designed to be possible to show on a dedicated display screen, which would be put up in stores (either at the till or at the security person's station), shown in Figure 34.

Figure 34: Prototype security elements considered to be designed as part of GlowPro (Raise incident screen)



On display :



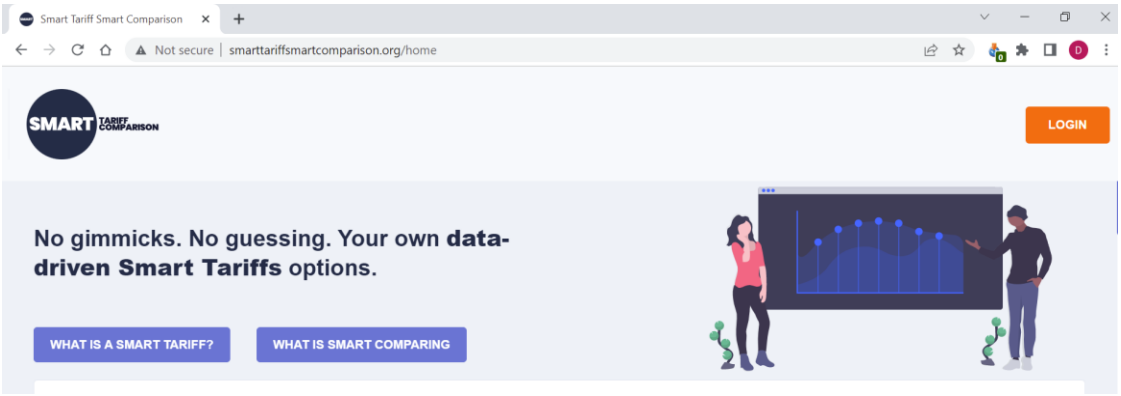
Outside of this, for the final prototype system development, Hildebrand mainly focused on ensuring the GlowPro prototype was ready for testing within the next and final stage of the Competition (protype user-testing roll-out). This involved development of a relatively straightforward semi-functional prototype of the system, which did not have different levels of access, as the full system intended to have, but provided a minimum viable product (MVP), which did not cost too much to develop, but was good enough such that it could be used for testing.

As is further discussed later on in this chapter and the next, by the end of the project, it was decided that the ND smart meter roll-out was too nascent for Hildebrand to develop GlowPro into a viable commercial system in the short to medium term. However, two other

developments occurred in the wake of the Competition project, which Hildebrand subsequently focussed on developing into commercial projects and services.

The first was developed off the back of the TPI exploration (see section 4.3.3). As described above, Hildebrand was a DCC other user and could, with a customer's permission, download 13 months of half-hourly energy use data. They used this functionality to develop a pilot smart tariff comparison tool (http://www.smarttariffsmartcomparison.org/home).

Figure 35: Hildebrand's smart tariff comparison site portal (Hildebrand Technology Limited, 2021)



This pilot-site enabled a customer to upload their data, which is then analysed and used to compare different smart meter tariffs which would be best suited to the customer. This is particularly interesting in the ND sector as they have different (and potentially greater) opportunities to flex their demand than households and could take advantage of time-of-use (TOU) tariffs, which may give them improved energy deals.

The second development involved developing hardware with a partner organisation to enable sub-metering solutions, which could be installed within the consumer unit at business premises to enable submetering of different equipment (Figure 36), following on from the findings in the interviews with SME owner-managers described in section 4.2.2.2.

Figure 36: Easton Europe (2021) SDM120DB Single Phase 45A MID submetering solutions[67]

[67] https://www.eastroneurope.com/products/category/din-rail-mounted-metering

These developments are obviously different to those the NDSEMIC Competition explicitly desired, but they did evolve as a consequence of the team undertaking the Competition project. These developments are further discussed in chapter 6.

4.4 Applying an entrepreneurialism lens to the Hildebrand Team's activities

This section analyses the findings through the lens of SME entrepreneurialism, including the three related theoretical frameworks; Effectuation, Causation (Sarasvathy et al., 2008, Sarasvathy, 2001a), and Absence of Strategy (Inkpen and Choudhury, 1995), which are described in detail in the literature review (Chapter 2). As described above, I had experienced Hildebrand and their team acting in entrepreneurial ways, whilst working on the Competition project, which had a marked influence on their activities during the development of GlowPro. As described above, these activities often related to activities and decisions made by the team, which I found to be unexpected. This led me to investigate literature about SMEs and entrepreneurialism within business management research. Sarasvarthy's research exploring effectual decision-making and its contrast to causal decision making which is more often observed in large businesses, appeared to chime with what was occurring. As a reminder, Causation aligns with a traditional view of entrepreneurship whereby decision-makers first set a specific goal and then take whatever actions necessary to achieve it. It aligns with classical definitions of setting out and then delivering on a strategy, in that it is a) explicit, b) developed consciously and c) made in advance of specific decisions (Mintzberg, 1978). There are five principles of Causation, which include: **Goal-driven** (drivers related to a pre-defined goal); **Expected-return** (choosing options based on calculated expected returns); **Competitive-analysis** (competitive analysis to reduce uncertainty); **Avoiding-surprises** (avoid, overcome or adapt to unexpected events) and **Predictive-trends** (socio-economic trends are the primary driver for creating opportunities). By contrast, Effectuation is an entrepreneurial logic which follows a dynamic and interactive process for the creation of new artifacts.

Sarasvarthy introduced Effectuation and contrasted it with Causation, describing that Effectuation is based on "*the effects of resources, capabilities, entrepreneurial orientation and learning on company performance*" (Sarasvathy, 2001a). There are also five principles of Effectuation; **Bird-in-hand** (creating solutions with the means available); **Lemonade** (mistakes and surprises happen and can be used to look for new opportunities); **Crazy-quilt** (Partnerships can bring new funds and new directions); **Affordable-loss** (you should only invest as much as you are willing to lose) and finally **Pilot-in-the-plane** (you can influence the future with your actions). Each of these phenomena have been developed through

previous research investigating entrepreneurial behaviours, particularly within the last two decades.

4.4.1 Team behaviours relating to Effectuation

Applying Effectuation coding to the fieldwork data showed that the Hildebrand team's activities were dominated by Effectuation, examples of which are shown in Table 2. Looking at the data through this lens helped make more sense of what had happened. For example, Hildebrand already did business with shopping centres (via their Wi-Fi-provision), which gave them helpful access to retail and hospitality businesses (*bird-in-hand*), and shopping centre managers who supported energy management locally as engaged partners (crazy-quilt) could help them to inform the development of GlowPro. Shopping centres also acted as an accessible conduit to access many retail and hospitality businesses via their occupants, thereby representing a more affordable and pragmatic way to engage them, as opposed to directly targeting the businesses themselves[68] (*affordable-loss*). In a similar vein, the framework also helped to explain the team's desire to explore new possibilities with partners which emerged along the way opportunistically (*lemonade, crazy-quilt*), particularly if they aligned with existing available resources, such as those enabled by Hildebrand's DCC other-user status (*bird-in-hand*). Finally, the Effectuation framework, being means rather than goals driven, also helped explain Hildebrand's propensity and willingness to 'flex' the desired outcomes of the Competition within GlowPro away from improving energy management directly and into other operational issues. For example, the Competition was helping them develop GlowPro as a system, which was the focus of development for Hildebrand, who were keen to give it the best possible chance of success even if it ended up doing things which did not directly relate to improving energy management (e.g. its use as a security system).

[68] Which, as described above required targeting through their head office teams and proved very difficult given the intervention was being developed and tested locally within only one or two of their premises affected.

Table 2: Coding matching the theme of Effectuation (Sarasvathy, 2001a)[69][70]

Code group	Definition	Examples	Literature upon which code group is based
Bird-in-hand	*To what extent was the underlying driver for a project related to currently accessible resources?*	- HB118: Evolving an existing hardware system and platform (IHD domestic monitor displays) to develop GlowPro system. JW2829: Leveraging Competition resources, meeting new collaborators and networking at NDSEMIC events	(Sarasvathy and Dew, 2005, Read et al., 2009, Pawęta, 2016)
Affordable-loss	*To what extent were risks and currently free cash considered in the decision process?*	- JW1229: Careful, staged system development to mitigate costs "*we have a core set of functionality that will be put live in v 1.0 [*GlowPro prototype]. *In parallel, we need to understand what goes into the next iterations and when - so this is about validating the requirements... Bill payer is key for v1.0. No smart meter data means no gas, no billing level accurate data.*" - JW14128: Investigation into TPIs and development of smart meter data based tariffs concept, with a view to potentially disrupting TPI market.	(Sarasvathy and Dew, 2005, Read et al., 2009, Pawęta, 2016)
Partnerships (Crazy-quilt)	*Relying on partners, commitments, and communication to reduce uncertainty.*	- JW1098: Working with existing clients (e.g. shopping centres) to reduce project delivery uncertainty - JW469: Working with large retail franchise (introduced through NDSEMIC Competition partner contacts) to help recruit retailer sites within their network to test GlowPro	(Sarasvathy and Dew, 2005, Read et al., 2009, Pawęta, 2016)
Leverage (Lemonade)	*When something appeared to be different than expected, it was used to explore new opportunities.*	- JW20118: Identifying the potential value of sub-metered data to customers; informed exploration of new hardware development to sub-meter important equipment (e.g. cold storage equipment vs HVAC and other kitchen equipment in the case of Hospitality premises) - JW9118: Exploring the TPI market (SME energy brokers) identified potential for a smart meter tariff comparison site to disrupt this business model.	(Sarasvathy and Dew, 2005, Read et al., 2009, Pawęta, 2016)
Human agency (Pilot-in-the-plane)	*Human agency is seen as the prime driver of creating business opportunities.*	- JW329: Broadening GlowPro functionality to include temperature sensors to improve GlowPro system utility for customers (e.g. cold-storage and internal temperature logging) - JW 1819: Further research to investigate and scope security system needs and potential features. Exploring idea with shopping centre managers: "Additional thoughts: *Really like the store messenger potential functionality to use GlowPro as a site communications system for disseminating security alerts*"	(Sarasvathy and Dew, 2005, Read et al., 2009, Pawęta, 2016)

[69] Codes (e.g. HB118) relate to instances within the data using a numbered system of coding specific coding.

[70]

Coding the data in this way showed that Effectual behaviours dominated the activities undertaken by the team working together on the development of GlowPro (see Figure 37), and Table 2 provides examples to demonstrate it. This aligned with the literature, whereby others have found Effectuation (vs. Causation and other decision frameworks such as Absence of Strategy[71]) to dominate within decision-making contexts, which involve new product or business development (called artifact creation) (Nummela et al., 2014, Smolka et al., 2016, Vershinina et al., 2017).

Whilst Effectuation behaviours dominated activities (See Figure 37) other strategic behaviours, including Causation and Absence of Strategy, were observed, which are discussed in the following sub-sections.

[71] Which is discussed further later on.

4.4.2 Team behaviours relating to Causation

As described above, within the development of GlowPro, Hildebrand flexed the project's outcomes to be broader than energy management. When I discussed this with Jane (and the potential conflict this posed for the NDSEMIC Competition goals), she stressed that this was done for pragmatic reasons, principally because they believed that GlowPro would not be successful without doing it. She described that their overall goal was to help the market improve energy management, which was the reason for their longstanding interest in developing smart meters. This was evident from their previous and subsequent activities relating to NDSEMIC, much of which has focused directly on smart meters and energy management, which appeared therefore to be a Causal ambition. Within the context of the NDSEMIC Competition, Jane described that they were always thinking about this, but their most pressing challenge was to make the system useful for their target audience; once they had achieved this acceptance, they would return to focusing on how they can support energy management in more detail.

There were other areas where finding ways to improve energy management was explored in a manner which appeared more causally focused. For example, in exploring potential 'hooks' to help customers benefit from improving energy management, we explored the potential for exploiting the Energy Technologies List (ETL), which is a source of advice for tax and energy-efficiency equipment procurement[72]. The team persuaded BEIS to look into potential opportunities to link to and/or promote the ETL, which hadn't previously been on the Competition's agenda. Furthermore, the development of sub-metering solutions, which emanated from the project (see section 4.3.5) evolved out of better understanding smart meter data, and its current relative inability to be able to disaggregate energy demand from different types of equipment[73].

In other areas, the Competition appeared to enable the team to undertake competitor analysis, for example it felt improbable that Hildebrand would have undertaken the energy consultancy market research (section 4.3.2), but the Competition resources, some of which

[72] The ETL, until 2020 served as a UK Government approved list of technologies, which qualified for tax-saving Enhanced Capital Allowances (ECA).

[73] The potential for using non-intrusive load monitoring (NILM) approaches was actively explored by Hildebrand during the Competition, but unfortunately they came to the conclusion that it wouldn't be possible to use such techniques within the scope and timescales of the Competition (Huber et al., 2021).

were expected to be used for research enabled them to explore this market, which otherwise was unlikely to have occurred. Finally, outside of the Competition, Hildebrand developed a 'white labelled' version of the GlowPro system, similar to their domestic in-home display (IHD) display they provided commercially to several energy suppliers for a new non-domestic energy supplier. This activity appeared to have occurred based on expected returns resulting from having delivered several of these types of contracts for suppliers in recent years.

Table 3 Coding matching the Causation theme (Sarasvathy, 2001a)[74]

Code group	Definition	Examples	Literature upon which code group is based
Goal driven	To what extent was the underlying driver for a project related to achieve a previously defined goal?	- CT1519: Exploration of GlowPro uses, to improve energy management directly, for example site-based energy benchmarking; data analysis to support identification of savings opportunities; energy profile insights for suppliers/ brokers (TPIs) to identify appropriate tariffs (e.g. time of use). JW17128: Exploring potential use of the Energy Technologies List (ETL) as a means of recommending take up of energy efficient equipment JW2219: Goal driven project management of Competition project delivery to meet required delivery timescales	(Read et al., 2009, Berends et al., 2014a, Smolka et al., 2016)
Expected returns	Calculating expected returns in order to choose from different options.	- JW2829: Exploring commercial opportunities alongside the Competition project, based on a white-labelled version of GlowPro with non-domestic energy suppliers	(Read et al., 2009, Berends et al., 2014a)
Competitive analysis	Relying on plans, opportunity costs, and competitive analysis to reduce uncertainty.	- JW18128, 22128, DK22128: Investigation into current energy consultancy business models and TPIs to understand whether and how GlowPro could support and/or disrupt existing business models "Business size – there is definitely a size cut-off, where it becomes not cost-effective to provide these services (he estimated a floor area of <100m2 cut off from a portfolio perspective, but not a kWh one)."	(Read et al., 2009, Berends et al., 2014a)
Avoiding surprises	Avoid, overcome, or adapt to unexpected events.	- JW3112: Avoiding developing system in ways which could potentially mislead or irritate customers, for example alert notifications. "*Reliable alerts, if they give false alerts they are more of a problem than not offering them. Set your own alerts with the boundaries around them - e.g. if I want to know that the coffee machine is on by xx time, that would be very helpful (until disaggregation is viable)*."	(Dew et al., 2008, Read et al., 2009)
Predictive trends	Socioeconomic trends and technological trajectories are seen as the prime driver of creating business opportunities.	- JW3188: Exploring how to provide energy based predictive trends within GlowPro outputs for interested customers (e.g. SCMs) "*Tell me what I can change and make me aware of what I can't change*". Keen to see the output of the data analytics being done on their data	(Read et al., 2009, Berends et al., 2014a)

[74] Codes (e.g. CT1519) relate to instances within the data using a numbered system of coding specific coding.

4.4.3 Team behaviours relating to Absence of Strategy

As a reminder, as described in section 2.7, Absence of Strategy theory developed as a another phenomenon of interest in strategic management. It is defined by Inkpen and Choudhury as to be "*a stream of decisions to a strategic context without an observable consistency*" (Inkpen and Choudhury, 1995). Different types of decision types within the Absence of Strategy theme have been described. These include **putting-out-fires** (was decision making forced by an unexpected event?)**, blinded-by-the-light** (were risks and possible returns not adequately considered?)**, walking-alone** (were relationships with stakeholders not adequately considered?)**, dead-end** (unexpected events have negative effects) and **no-control** (the future is not controllable) (Aram and Cowen, 1990, Robinson and Pearce, 1984, Beaver, 2002, Klingebiel and De Meyer, 2013, Svensrud and Åsvoll, 2012)**.**

I observed a few instances of decision making which aligned with Absence of Strategy whilst working with Hildebrand. It could be viewed that the development of the GlowPro system in its prototype guise developed by the end of the Competition turned out to be a dead-end and as such comprise strategy absence. However, that is likely an overly negative and incorrect interpretation, as looking at it from outside of the context of the NDSEMIC Competition, it made more sense to consider this Effectuation (affordable-loss). The Competition enabled the team to explore a riskier idea, which they unlikely would be willing to do had Competition resources not been provided to enable it. In addition, other opportunities, which appeared more commercially promising had arisen directly out of participating in the Competition, such as the ND smart tariff comparison site and submetering solutions (section 4.3.5).

Later on, during the roll-out testing of the GlowPro prototype, some Absence of Strategy (putting-out-fires) was observed, for example, regarding Wi-Fi connectivity issues at premises, where many difficulties were had in obtaining the monitoring data after installing the GlowPro hardware. Furthermore, overall the lack of smart meters due to delays relating to the smart meter roll-out (Money Saving Expert, 2019) (and lack of ability to easily determine what existing types of meters were installed at sites, where testing was done) was an issue which was consistently a significant issue for the project (no-control) which was outside of the team's control. Table 4 provides examples of codes relating to the Absence of Strategy theme.

Table 4: Coding matching the absence of strategy theme (Inkpen and Choudhury, 1995)[75].

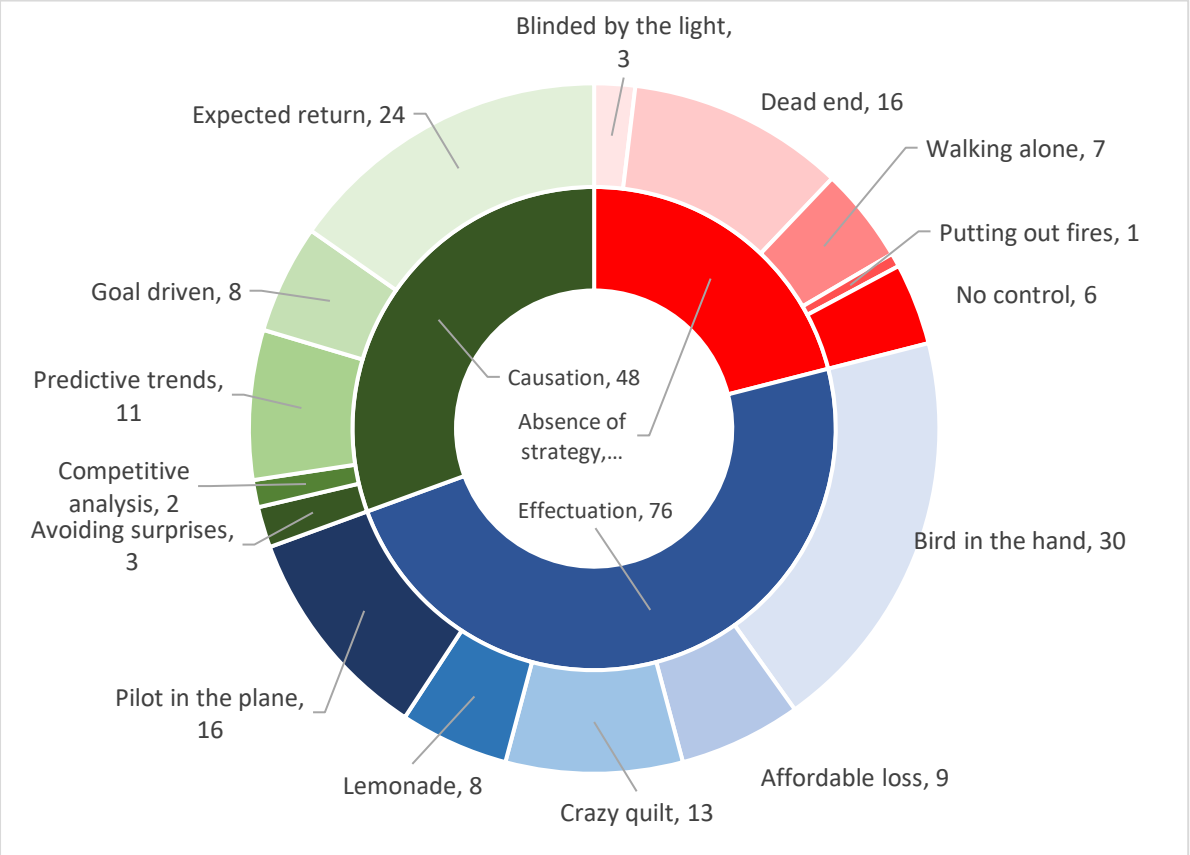
Code group	Definition	Examples	Literature upon which code group is based
Putting out fires	To what extent was the decision forced by an unexpected event?	JW629: Installation and connectivity issues "*The same issue that arises with Wi-Fi in these buildings will also arise with our device. They tend to have a lot or brick and concrete walls, and what can be a major issue is the fact that a lot of them have their electricity meters behind the kitchen. Kitchens being packed full of large metal objects block signal very well.*"	(Aram and Cowen, 1990, Robinson and Pearce, 1984, Beaver, 2002)
Blinded by the light	To what extent were risks and possible returns not adequately considered?	JW2158: Unexpected, challenging evolution of shopping centre market. "..[Commercial landlord].. *market update also highlights how large, under-utilised, spaces owned by retailers are being looked at to produce income in other ways (we saw an example of this at ..*[GlowPro site]*.., where..*[clothes retailer]*.. has sublet some of their space to an in-store branch of .*[Leisure business]... "	(Robinson and Pearce, 1984, Beaver, 2002)
Walking alone	Relationships with stakeholders are not specified.	JW1999: Difficulties in developing and maintaining relationships with large retailers (e.g. franchises) to support them in rolling out installation and use of GlowPro. "*She has only been able to get an answer from one store who declined. They indicated that they had not received any campaign from ... [partner]*"	(Aram and Cowen, 1990, Beaver, 2002, Bryant, 2007)
Dead end	When something unexpected happens with a negative effect on the outcome and the company in general.	JW15109: Challenges installing GlowPro system with some retailers. "*"The shop is family owned, the son, Andy's contact wanted to technology fitted as he was interested. When I showed yesterday, only the father was present and categorically refused anything to do with a Government trial* "	(Klingebiel and De Meyer, 2013)
No control	The future is seen as determined by luck and as such, every attempt to take control of it will fail.	JW129: "*JG went to …[site]... to review the 8/10 shops which have 'smart meters'... all AMR*"	(Svensrud and Åsvoll, 2012, Klingebiel and De Meyer, 2013)

[75] Codes (e.g. JW629) relate to instances within the data using a numbered system of coding specific coding.

4.4.4 Overview of themes relating to Effectuation, Causation and Absence of Strategy: Hildebrand team

One of the criticisms of the above-described entrepreneurialism theoretical frameworks is that they have not been extensively tested empirically. Hauser et al. (2020) took an approach to empirically explore and test all three entrepreneurialism frameworks together, with the purpose of helping to empirically delineate Absence of Strategy from Effectuation, the two of which are sometimes confounded. I emulated this approach (an overview of which is shown in section 2.7.6) here to see how my work with Hildebrand compared with existing literature. Figure 37 shows an output from systematic coding of all of my fieldwork data generated whilst working with Hildebrand. The chart shows that Effectuation behaviours dominated activities and related to 76 out of a total 157 codes (48%), Causation related behaviours accounted for 48 (31%) codes and Absence of Strategy 33 codes (21%).

Figure 37: Patterns in the context of GlowPro development activities; Effectuation, Causation and Absence of Strategy (Hauser, 2020)[76]



[76] Chart numbers refer to the number of instances where the observed behaviour was coded within the data (for example, 'blinded by the light (strategy absence) was coded 3 times out of a total 157 codes.

When these frameworks have been subject to testing with SMEs, issues have been identified whereby empirical data has not 'fit' adequately with existing frameworks and some of this work has helped further evolve the frameworks (Hauser et al., 2020). Similar to Hauser, I also found that whilst the frameworks provided a very good fit for the data, there were aspects which did not fit so well in the context of analysing my data, which is discussed below and further within the discussion (Chapter 6).

Firstly, working with Hildebrand was dominated by Effectual decision making and whilst as described above, Causation and Absence of Strategy were also present; the *extent* or *dominance* of Effectual behaviour appeared surprising. For example, Hildebrand got very excited by the investigation into TPIs. They were very interested and surprised at what appeared to be very high-profit margins being made by TPIs, alongside what they perceived to be antiquated marketing activities (e.g. telephone cold-calling SMEs) to gain and keep customers. They spent considerable time and energy exploring the potential for disrupting this market, bringing in their new status as a DCC other user. Whilst this was all undertaken outside of the auspices of the NDSEMIC Competition, it felt surprising how much effort and time went into exploring this particular finding and their interest in the potential opportunity to disrupt what they perceived to be a profiteering and unfair market, whereby SMEs were getting a poor deal. When relating this to the definitions and examples of Effectuation described by Sarasvarthy and others, their activities appeared to be *Enhanced Effectuation*. Whilst this was not overtly discussed by the team, it appeared like these activities were enabled to a degree because they had funding from the Competition, which lowered the risk to their business of exploring the opportunity, thereby influencing their interpretation of what 'affordable loss' meant to them at the time.

Secondly, previous researchers have investigated how these phenomena vary according to different contexts. Some have demonstrated that larger organisations tend to be more Causal (Nummela et al., 2014), whilst others have criticised this and shown that very large organisations such as Google also demonstrate many Effectual behaviours. More recent evidence suggests that decision-making changes according to decision context, identifying that Effectuation dominates when businesses are developing new products or services (known as *artifact creation*), and more Causal behaviours dominate when maintaining existing services (*maintaining existing artifacts*, otherwise known as 'business as usual'

activities). What was surprising here was that it appeared that many Causal behaviours were present, alongside Effectuation in Hildebrand's activities (Figure 37). This may be due to several different factors; for example, the fact that GlowPro development was underpinned by Government innovation funding, which had very specific and explicit desired outcomes to improve energy management. These issues, including decision contexts, are explored further in Chapter 5 and discussed in greater depth within the discussion and conclusions in Chapter 6.

5 Findings part 2 – testing GlowPro and exploring smart meter and other data with owner-managed SMEs

5.1 Chapter introduction

This chapter describes findings relating to testing the GlowPro prototype and further explores the potential for smart meter and other data with target SMEs within the retail and hospitality sectors. This was done by undertaking two further cycles of inquiry in a similar fashion to that undertaken with Hildebrand in Chapter 4. However, this time I worked with three independent owner-managed SMEs in retail (a cycle-shop chain), hospitality (a coffee-shop chain) and small industry (a coffee Roastery). I recruited these businesses independently, although they also supported Hildebrand by contributing to the overall number of test sites included in the final stage of the NDSEMIC Competition[77]. Each business agreed to participate in testing GlowPro, providing access to a sub-set of their premises to install the GlowPro equipment, monitoring them and engaging in discussions surrounding this to explore the potential for using smart meter and other data within their businesses.

Further details of the approach are described in the methodology chapter, section 3.7, sub-section 3.7.3. However, as a brief reminder, the fieldwork involved 1) in-depth interviews with owner-managers to get to know them and gather contextual information and agreement as to which sites would be monitored, 2) site visits to install monitoring kit and observe activities on site 3) semi-structured interviews with owner-managers and other staff to introduce GlowPro and explore reactions to it and 4) further in-depth follow up interviews to explore potential broader uses for smart meter and other data.

Learning from previous cycles of inquiry undertaken in part 1, the research was undertaken inductively, broadly discussing issues raised and by the businesses in the way they saw them, with minimal directive input from me[78]. This emulated aspects of the approach favoured by Hildebrand previously, exploring participants' contexts from their perspective to fully understand this, before exploring specific issues of interest to me in more detail. However, I did consider entrepreneurialism theory more actively during part 2, exploring it in greater detail as it interested me and because it felt natural, given how the owner-

[77] Hildebrand committed to testing the GlowPro prototype with over 50 businesses within the final phase of the NDSEMIC Competition.
[78] Other than when discussing specific elements, such as introducing GlowPro.

managers described their organisational behaviour, so this is reflected in the sub-sections below.

The following sections are structured as follows. The chapter commences with the first inquiry-cycle (section 5.2). This includes an overview of the businesses (section 5.2.1), followed by summaries of the respective histories of the businesses and their evolution into their current states (5.2.2) and a retrospective analysis of owner-manager decision-making. This is then followed by an analysis of current management practices and decision-making (section 5.2.4), including management of people (staff); premises (including management of the internal environment) and; performance, including profitability and costs (including energy management). The analysis is followed by reactions to the GlowPro prototype, after monitoring a sub-set of each business premises (section 5.2.5) and finally, a summary and reflections on the first inquiry-cycle (section 5.2.6).

The second inquiry-cycle commences with an exploration of broader uses for smart meter and other data (section 5.3), which includes staff and operational management; health and safety and management of the internal environment; marketing; energy management and finally exploring integrating smart meter data and other into existing management systems. Then an analysis applying Hauser's entrepreneurialism framework to the findings is described (section 5.4), final reflections (section 5.5) and a final summary of findings (section 5.6).

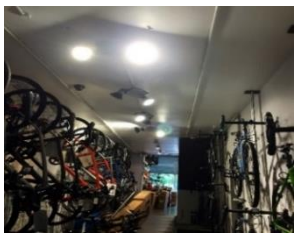
Throughout the chapter, where findings align with a specific entrepreneurial heuristic, this is noted in parentheses (e.g. *Effectuation, bird in the hand*). The businesses and their staff have been anonymised, and pseudonyms are used to protect the identities of staff involved in the research.

5.2 Cycle 1 – owner-managed SMEs and testing the GlowPro prototype

5.2.1 Overview of the owner-managed SME businesses

Each business was owner-managed and set up from scratch by the current owners. An overview of each business is shown in Table 5.

Table 5: Overview of the three owner-managed SMEs

	Coffee businesses holding company		*Cycle-shop chain*
	Coffee-shops	*Roastery*	
	 	  	 
Year established	2007 (SW coffee-shop), 2012 (London coffee-shops)	2009	2006
Number of premises	1x coffee-shop (SW England), 2x coffee-shops (London)	1 (SW England)	3 (London) in the process of expanding to 4 during fieldwork
Number of employees	15	10	20
No. GlowPro monitored premises[79]	1	1	2
Inquiry-cycle participants (pseudonyms)	- Mara (Owner and SW coffee-shop premises manager) - Josephine (London coffee-shop owner and holding company chief operating officer (COO) - Cornelia (holding company finance manager) - Mike (roastery premises manager) - Mickey (London coffee-shop premises manager)		- Oliver, cycle-shop owner/manager

[79] The pictures included in the table show premises which were monitored.

The cycle-shop chain had three premises[80] located within a five-mile radius in the inner South London suburbs. The business was 100% owned by Oliver, who set it up in 2006 when he was in his early twenties, driven by a passion for cycling and mountain biking. At the time of fieldwork, Oliver was in the process of creating a new partnership with another independent cycle-shop chain, which involved expanding to a new premises, with more planned in the longer term. Within the current business, each premises had a similar set-up, with display space for bikes and cycling accessories sales and a larger back room or basement, where servicing and repairs were done. The business had fifteen employees, approximately evenly distributed across the shops, each having a premises manager and 3-4 cycle mechanics, who were sometimes shared across shops when required (e.g. to cover annual leave or particularly busy periods). Oliver managed the business overall, providing cover for premises managers where needed and being supported by a contracted accountant, who did bookkeeping, tax returns and prepared monthly management accounts. Oliver described that whilst the displays attracted customers to the shops, about 80% of their profits related to cycle servicing and repair work, as opposed to selling bikes. This was their niche in the market, as it was hard to be price competitive with larger and online bike retailers (such as Evans Cycles[81]); they were much better able to provide local high-quality and trusted repair and maintenance services. He described that they had long-term loyal customers who regularly came for bike servicing and maintenance. Oliver was the main cycle-shop participant in the inquiry cycles, but I also got to spend time with and interview other staff, including both premises managers at the two shops where GlowPro was installed.

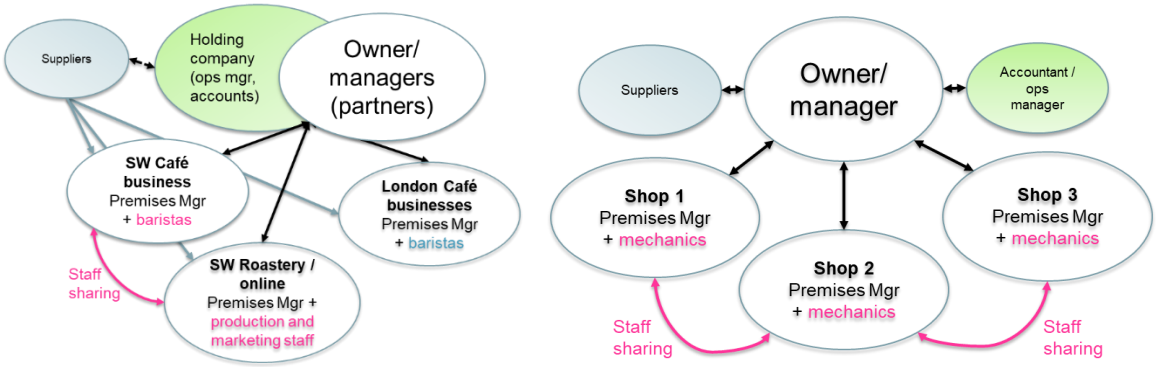
The coffee-shop chain and roastery had four customer-facing premises, comprising three coffee-shops (two in London and one in a city in the South West of England) and a coffee roastery industrial premises, also in the South West, about 30-minutes away from the SW coffee-shop. These businesses had a complex ownership profile, with a married couple (Mara and Tim) owning the roastery and SW coffee-shop and had set them up in the late 2000s. The London coffee-shops were separately owned by a small group of antipodeans, who set these up in 2012. The businesses, were part of a broader independent coffee

[80] Two of which were allowed to be monitored with GlowPro.
[81] A large UK-based bike retailer. https://www.evanscycles.com/

business portfolio, co-owned by the group (including Mara, Tim and Josephine, one of the London coffee-shop owners), which included five different ventures. These included supply of professional and home coffee equipment, as well as the coffee-shops, and Roastery. Whilst each subsidiary business had a slightly different ownership profile, they were all supported and managed by an over-arching holding company. The holding company was also co-owned by the same group of individuals and provided strategic oversight of each venture and administrative, finance and accountancy support. Each coffee shop had a premises manager, and four or five baristas, who worked on a rota, covering different shifts (e.g. early morning to early afternoon or mid-morning to day-end). The Roastery had approximately ten staff in total, with an operational manager and supporting production and distribution staff. When needed, staff sharing occurred between the London coffee-shops, and between the SW coffee-shop and the Roastery.

Within this overall structure, the main participants within the inquiry-cycles were the owner-managers, although they also included other staff, as shown in Table 5. I was allowed to install GlowPro at two sites, the roastery and the SW coffee-shop. The organisational structures of each of the businesses is shown in Figure 38.

Figure 38: Organisational structures: Coffee-shop chain and roastery business (left), Cycle-shops (right)



5.2.2 Business electricity demand

Table 6 provides a high level summary of the main electricity using equipment utilised at each of the primary monitored premises, including the SW Roastery, SW coffee shop and one of the cycle-shops[82]. Each of the businesses described that their energy bills were

[82] Two cycle-shop premises had monitoring equipment installed, however only one of these provided useful data as the Wi-Fi connection at the other way temperamental and was not possible to get working.

relatively consistent and that they formed a small proportion of their overall operational costs.

Table 6: Owner-managed businesses' summary of main electricity uses and estimated annual demand

	Coffee businesses holding company		*Cycle-shop chain*
	Coffee-shops	*Roastery*	
Summary of main electricity using devices at monitored sites	Espresso machines (x4) - large, integrated into main bar. Electric coffee grinders (x2). Under counter fridge (x2). Commercial glass and cup dishwasher (x1). Till and POS equipment (x1). Commercial water boiler (x1). Large fridge freezer - basement (x1). Alarm system. Stereo system. Lighting (mixture of LED and halogen spotlights in front of house, G13 tube lighting in basement).	Espresso machines (x3). Water boiler (x1). Electric coffee bean grinder. Lighting (all LED tube and spotlights). Fridge (x1). Fridge freezer (x1). Large coffee roasters (gas powered x2). Coffee bean hopper (x1). Industrial scale vacuum cleaner, Franking machine. Office computer work-stations (x6). Printer (x1).	Large HVAC system for heating and cooling in summer (x1). Till and POS equipment (x1). Computer workstations (x2). Printer (x1). Fridge (x1). Cycle cleaning equipment (x1). Alarm system. Stereo system. Lighting (high powered GLS spot lights x18) strip lighting in basement.
Estimated electricity demand of monitored premises (kWh)	6,100	14,500	5,350

I did not explore the businesses energy demand in great detail however for this study, for reasons described below. Previous research undertaken as a scoping study prior to this PhD (Kenington et al., 2019), had explored detailed energy contexts for individual SMEs by way of conducting a detailed energy audit of their premises, and then making recommendations for improving energy demand through a range of different actions. This study helped reveal that the main gaps in understanding revolved around connecting energy use with operational activities, as making recommendations without understanding the operational contexts involved with different uses of equipment and their respective energy demand appeared ineffectual. This resulted in focusing the main activities of the PhD on understanding strategic business contexts in order to help better understand how to influence energy demand more effectively. This meant that I did not plan to undertake detailed site-specific energy audits. However, I had anticipated that the GlowPro software would enable me to monitor electricity consumption over time, which would be relatable to the presence and use of on-site energy using equipment. Unfortunately, the GlowPro prototype monitoring data, was poor quality, with the Wi-Fi-connected current clamp equipment only working very sporadically over the period of time the equipment was installed. The equipment was prone to dropping the Wi-Fi signal, which meant monitoring data was lost, and batteries failed which also then required a site visit to update, as well as premises staff inadvertently un-plugging the equipment to use the plug socket (e.g. for vacuuming or other activities) and were not subsequently reconnected. On more than one occasion the equipment was damaged when things were moved around the premises and I had no idea what had happened until I visited again. This limited the extent to which the monitoring data could be used in practice. As a result, I mainly used the monitoring data to select 'excerpts' of successfully monitored days, which I could then print out and show as hand-outs to discuss with staff to explore them in detail.

I did ask for energy bills from each of the owner-managers, but was only able to obtain actual details from one of the businesses, and analysis of those bills helped identify issues with metering, which made it challenging to accurately estimate energy use and uses on each site. Because of this, I did not make any concerted estimates with regards to actual energy uses of each business. However, it was possible to make some estimates from discussing bills in general terms with the staff and reviewing what energy using equipment was on-site at each business.

Details on how businesses managed energy use is described in section 5.2.4.3.

5.2.3 History and evolution into their current businesses

This section explores how and why the owner-managers set up their businesses originally and how they evolved over time. This provides context within which subsequent findings are situated and in doing so, also describes some of their entrepreneurial characteristics.

Oliver had started his career working in an administrative role at the local council, but after a few years found it depressing and it spurred him to follow his cycling passion by setting up a cycle-shop. He described that taking out the lease on his first shop was very stressful, as he was committing himself to a long, expensive lease and had almost no direct retail experience. He researched the local cycling market in great detail to inform his plans, identifying the burgeoning trend towards cycle-commuting within inner-London suburbs of the time and exploring which geographic locations had limited existing capacity that he could fulfil. After setting up his first premises, he worked long hours managing the business and shop and doing most customer bike repairs himself until he had the cash and confidence to expand and hire staff. Since then, he had stuck closely to this original business model, leveraging his 'trusted' local advantage over larger competitors described above. In recent years, he had developed the business by employing a 'replicate and scale' strategy, expanding into different local neighbourhoods as he got more confident in his business model. In the last few years, with the assistance of his accountant, he felt he had gotten a better grasp of managing cash flow and profitability, which had been historical challenges. This helped him to understand when and how he could expand sustainably. He was now in a good financial position and keen to take advantage of this, which had inspired his new partnership venture, which he hoped would considerably expand his network in the next few years.

Turning to the coffee-shops and Roastery businesses, Mara and Tim had discovered the world of 'single-estate' coffee whilst working as baristas in Melbourne, Australia during travelling adventures they did together in their early twenties. As the name suggests, single-estate coffee comprises beans sourced from one farm estate and coffee variety, which opens up many possibilities for coffee connoisseurs in terms of different tastes and has a well-established following in Australia. It was upon returning home that they realised that this type of speciality coffee market did not exist in UK which inspired them to start up their first coffee-shop and, subsequently the Roastery.

Table 7 Coding matching the Causation theme across the three SMEs (Sarasvathy, 2001a)

Coding theme	Examples	Literature
Goal oriented	*It* [The UK coffee market] *wasn't about single estates and championing coffee as a quality product… we were the first to do single estate coffees here*. (Mara, SW Coffee-shop and roastery owner-manager)	(Read et al., 2009, Berends et al., 2014a, Smolka et al., 2016)
Competitive analysis	*We investigated the market for filtered water and discovered a gap, whereby nobody was producing a filter jug explicitly for coffee-making; but most coffee enthusiasts know that the quality of the water has a huge influence on quality of the coffee* (Josephine, London coffee-shop owner-manager)	(Read et al., 2009, Berends et al., 2014a)

Both the coffee-shop and roastery businesses had been highly entrepreneurial over the last decade, which had morphed into several separate ventures, including partnering with Josephine and her co-owners. Each of the businesses was designed to service different parts of the high-quality coffee market, serving consumers directly via the coffee-shops, an online equipment and coffee supply business, and indirectly, via wholesale beans and professional barista equipment to other specialist coffee-shops and the broader hospitality market. They had also developed a number of coffee innovations, including single-estate Nespresso style coffee pods and the development of a home water filter jug, designed specifically for water filtration perfect for coffee-making. They managed this by undertaking ventures with various partners they had come to work with along the way. In part, this is

where the development of the holding company, with subsidiary businesses with different ownerships profiles had come from. They viewed each venture as having its own strengths and weaknesses, and some were riskier than others, and enabling the sharing of resources across them was an effective way to manage the different businesses, whilst limiting their risk to the whole should one of them fail at any one time (Figure 38).

Analysing the data from an entrepreneurialism perspective, both Causation and Effectuation appeared to dominate decision making (

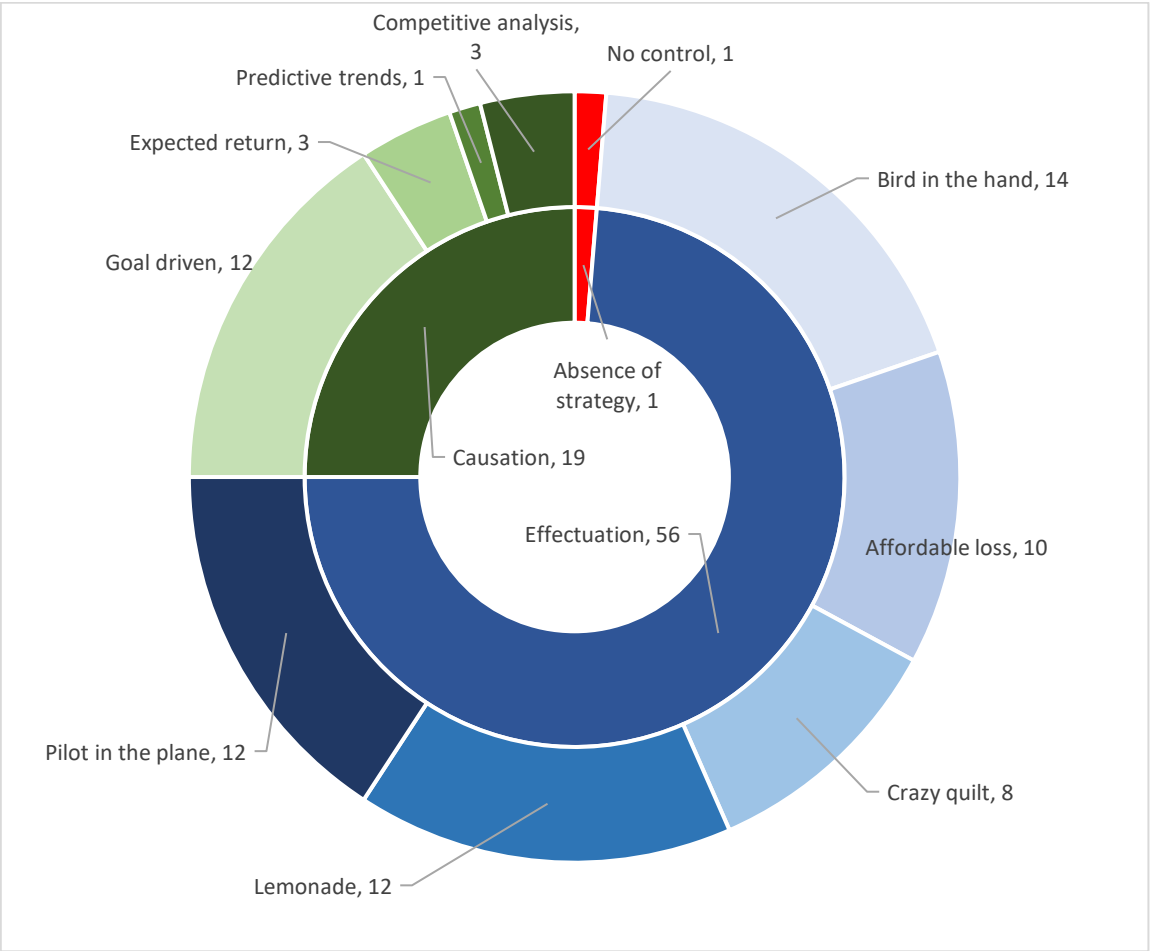
Figure 39) in the context of the evolution of the businesses over time, manifesting in different ways. Patterns of Causation dominated within the context of the desired goals of each business, which tended not to be dictated by profit-making, but life-style goals and passions, aligning with the findings of previous studies (described in section 2.7.4) (Anderson and Jack, 2000). That said, behaviours they described in *how* they achieved success were very much dominated by Effectuation, particularly in the case of the roastery and coffee-shop businesses. Experimenting with different approaches to see what worked and what didn't (Effectuation, lemonade) was central to evolving their offerings and investing small amounts initially (Effectuation, affordable loss), increasing over time when they met with success. This dominance of Effectuation aligned closely with existing studies (Sarasvathy and Dew, 2005, Hauser et al., 2020), which find Effectuation is most dominant in the context of business development or new product development (artifact creation).

Table 8: Examples of behaviours aligning with the Effectuation theme

Effectuation	**Examples**	**Literature**
Bird-in-hand	*We always did want to roast, but you know it takes time, there is a lot of infrastructure to set up, so it took use a few years of developing and growing before we had the resources to commit to it.*	(Sarasvathy and Dew, 2005, Read et al., 2009, Pawęta, 2016)
Affordable loss	*So we got our first, small roaster; we did this at the coffee-shop; at night after we had closed. We weren't? technically supposed to do it, as the area is within a smoke-controlled zone; so we did the roasting at night,*	(Sarasvathy and Dew, 2005, Read et al., 2009, Pawęta, 2016)

	experimenting at a small-scale until we were confident to develop further	

Figure 39: Patterns in the context of company founding and strategic owner/manager behaviours: Causation, Effectuation and Absence of Strategy (Hauser et al., 2020) [83]



Interestingly, as each of the businesses described how they became well established, they had focused more on how to achieve commercial success, which appeared to align with a trend towards more Causal behaviours. Growing confidence and scale, from which greater disposable resources became available, appeared to lead to greater Causation-led behaviours. For example, Oliver was now spending a considerable amount of effort and money researching new neighbourhoods to expand into, including investigating the business models and performance of competitor shops in different areas to understand

[83] Chart numbers refer to the number of instances where the observed behaviour was coded within this area of inquiry in the data.

whether and if so how they might be able to compete if they opened up a new premises nearby successfully.

The following section describes current staff and premises management practices, exploring day-to-day business activities and how they are managed.

5.2.4 Current management practices

This section describes current management practices in all three businesses, relating to people (section 5.2.4.1), premises (section 5.2.4.2) and business performance (section 5.2.4.3).

5.2.4.1 People management

As each business had evolved and grown over time into their current guises, their staffing structures and management had also evolved considerably. Without exception, each of the owner-managers had undertaken almost all of the roles undertaken by their staff previously and could step into these when needed. Mara and Tim (SW roastery and coffee-shop owner-managers) had, over time, evolved their substantive roles towards those which suited their individual skills and interests. For example, Mara oversaw the SW coffee-shop and operational issues, whereas Tim, who was more entrepreneurial by nature, focused more on developing innovative new ventures, often forging new partnerships with others.

Outside of the owners themselves, from a staff management perspective, each business had a relatively informal and relaxed structure but did include some level of hierarchy to give clear roles and responsibilities. For example, each of the cycle-shops had premises managers who took responsibility for managing mechanics/shop assistants and the coffee-shops each had a similar set-up. Developing and nurturing staff was one of the most important issues in determining success and took up considerable management time for all of the businesses. Premises managers delegated responsibilities to newer staff over time, which was key to succession planning, particularly when inevitably staff moved on from time to time.

Pretty much, anybody in this industry will tell you that staff turnover is one of the biggest issues. It's massive, especially in a city like London where people tend to be passing through and don't stay. (Mickey, London coffee-shop premises manager)

The London coffee-shops and cycle-shops had longstanding staff turnover challenges as it was difficult to attract and retain staff, given the expensive London wage market. Staff were usually young and transient, so they would often stay for only a year or less. Over time they had improved this by working hard to keep staff happy, making them feel 'part of the family'. Each of the businesses described formal approaches to recruitment, such as working with agencies; however, in practice, they relied heavily on informal approaches, recruiting friends and contacts of existing employees, particularly in their formative years.

From a day-to-day people management perspective, detailed weekly rotas were employed by all of the businesses. In particular, premises and operational managers in the coffee-shops and the roastery spent much time balancing staff to match predicted demand, which fluctuated considerably at different times of day (e.g. the early-morning rush required extra staff). The London coffee-shops, which had higher staff turnover and unpredictability, required close daily management and 'fire-fighting' from premises managers when there was last-minute absence, often due to sickness. Within the roastery, there was a need to cater for very large swings in demand for roasted beans, particularly when large wholesale orders came in (which tended to occur irregularly and usually at short notice). Here, staff sharing with the SW coffee-shop was utilised to get 'all hands on deck' to get an order out (which often also required weekend working from time to time). As is typically found within SMEs, staff may have 'core' roles that they were recruited into, but day-to-day, this is often flexed to manage a variety of business needs, so they can expect to be put into a broad range of different roles as and when the need arises, with very close management by senior staff (Solberg et al., 2021, Černe et al., 2017).

5.2.4.2 Premises management, including management of the internal environment

Business owners and premises managers managed their sites tightly with highly specified approaches to ensure they could provide consistently high-quality service whenever they were open, as well as making sure the premises were welcoming, attractive and comfortable environments to come into for customers in the case of the retail sites.

Managing processes

Within the roastery, production processes were managed very closely, such that each run of the roasting machines effectively used the equipment within the working day. For example,

there would be weekly meetings where all production staff would discuss and make plans for the coming week as far as possible. What was challenging about it was that all roasting was done to order, ensuring the product was as fresh as possible. This occurred both for strategic and pragmatic reasons. From a strategic perspective, the roastery marketed itself on quality, ensuring beans were freshly roasted each time they were ordered. From a pragmatic perspective, the site managers also did not want to give up lots of the space towards storage, which they would need if they were to pre-roast stock before orders came in[84]. As described above, demand fluctuated considerably, which often disrupted regular planning and meant that day-to-day revisions were constantly needed, and working times and staff sharing would be flexed to manage when needed.

The coffee-shops also experienced demand variability, although with greater immediacy due to the need to serve customers there and then. For example, one of the London premises could serve either 150 or up to 500 cups of coffee per day depending on the day of the week, weather and other factors. Variability was also reflected within the roastery, albeit on a slightly longer time-scale. The nature of orders was described as being unpredictable and 'lumpy', especially on the wholesale side of the business, where a large order could come in and immediately turn a quiet week into one which required out-of-hours production runs, such as on the weekends. The cycle-shop chain tended to be more predictable on a day-to-day basis; however, this was largely down to the main activity being cycle servicing and there being a relatively constant resource constraint in terms of mechanic staff and time availability across the week. Whilst there would often be large spikes in demand for servicing, as there was limited resource available, this would mean that bookings would be taken further in advance, and if it was too long away for customers, they would then often go elsewhere for their servicing needs (much to Oliver's chagrin).

The management of on-site energy-using equipment was directly related to on-site processes. In the context of the coffee-shops, needing to be ready for customers at any time meant that all the coffee machines, dishwashers and other equipment were perceived to need to be on at all times.

[84] Some considerable space within the premises was dedicated to storage of unroasted 'green' beans, however this was also closely managed to ensure these were also still fresh before roasting (see pictures, Table 5).

Well, we do it throughout the day [using the dishwasher for cups and glasses]*. It's going pretty much all the time. I'll show you in a minute. As soon as people finish, we collect up the stuff. We try and make sure its full before we put it on. The cycle isn't very long – about a minute and a half. It's like a really fast, commercial machine… We call it Cinderella!* (Mara, SW coffee-shop owner-manager)

The water boilers, in particular, required 15-30 minutes of warm-up time, so whilst they were turned off at night to reduce energy use, they were kept on all of the time during business hours. There was a quality management aspect to this, whereby it had been noted as a problem if staff had forgotten to turn on the boilers before opening time, which meant that poor quality coffee was being served for the first part of the day. This was an important and often busy time, as this was when commuting 'regulars' bought their coffee on the way to work.

Managing the internal environment

As described above, customer-facing premises in particular needed to be welcoming at all times. In practice, this meant considerable attention to detail was paid to ensure premises were accessible, clean and attractive.

[Referring to coffee-shop internal environment] *Yeah, its massive – especially when opening at a new location, it's right at the top of the list, ensuring that the atmosphere is great and that it is aesthetically pleasing. Obviously, personal preference comes into it based on the different companies, but definitely, it's really important.* (Mickey, London coffee-shops premises manager)

As found in previous research, considerable time and money was spent on ensuring this (Kenington et al., 2019). For example, lighting was carefully managed, such that it was not too bright or dim, prioritising natural light where possible. The lighting hue was also carefully considered ensuring different areas of the premises were lit appropriately, for example, ensuring seating areas had various lighting sources, minimising any glare on surfaces, which could dazzle customers or make them feel uncomfortable. Areas where products for sale were displayed needed to be brightly lit to show them at their best, with minimal shadowing. One of the London coffee-shops was described as being very difficult to get the lighting correct as it was very dark in places, and a lot of time and money was

spent experimenting with different types of uplighters and downlighters to get the lighting well set up, ensuring that customers would feel comfortable (and could see!), wherever they sat.

Each premises manager, described different challenges they experienced in managing the internal environment, especially regarding temperatures. These challenges were, for the most part, related to keeping sites cool in summer as opposed to keeping warm in winter. Mara, the owner-manager of the SW coffee-shop described that as the site used to be an art gallery it was very light and airy (see picture, Table 5), principally due to four large skylights which had been put in to the site when it was extended from the original Georgian front shop in the 1970s. This was great as far as they were concerned because the space was very light and bright from an ambience perspective during most of the year. However, unfortunately, the skylights could not be opened, which caused problems for managing internal temperatures in summer. The landlord had had them nailed shut during the previous tenancy, as when the premises was a gallery, thieves had got in through the skylights and stolen some valuable artworks. Being on the south side of the building and in direct sunlight, they acted like a greenhouse in summer, making it very hot inside. This was particularly difficult for the staff behind the counter as the sun would shine directly in their faces, dazzling them during the middle of the day. She discussed that as the premises had two floors and side windows, they would manage ventilation by opening the windows and doors of the basement and the rear garden door and side windows on the shop floor, which allowed a breeze to flow through and mitigated the temperature. They had previously discussed getting air conditioning, but they did not want to do this as it tended only to be a few days of the year when it was unbearably hot, and much more often the climate was rainy and cold. Similar issues were described in other premises, including one of the cycle-shops, which had large south-facing windows where they had eventually installed air-conditioning to better manage temperatures (despite the use of a large awning, which provided helpful shading).

From an entrepreneurialism perspective, premises processes and internal environments were managed in a Causal manner wherever possible for different reasons and in different ways. However, Effectuation was also 'built-in' to these activities, so they could respond to changes in demand and activities swiftly and easily as needed. Each premises had specific

challenges when it came to managing the internal environment, and this was an area where some elements of Absence of Strategy were also evident (e.g. suffering from summer over-heating in the SW coffee-shop).

Yeah. And you know we could get them unbolted, and every year when summer comes round we say we really need to do that because its gets so hot in here…. Because when the sun gets over those two properties over there, oh my god it's like a greenhouse in here!
(Mara, SW coffee-shop owner-manager)

5.2.4.3 Performance management, including profitability and costs (including energy)

The businesses all had a range of activities they regularly undertook to manage performance, where they considered how to improve profitability or reduce costs. These activities were specific to each business; some performance elements were managed at a premises level and others centrally across the whole business. These approaches had evolved over time through experience and after some 'trial and error', for example, when the businesses had experienced challenges, such as cash flow problems, profitability issues or serving demand problems.

The coffee-shops and Roastery businesses used quite a formal approach for performance management, using the holding company and its managers to hold monthly or more regular management meetings with premises managers. These meetings would be prepared for in advance, whereby the managers would provide recent sales and management data, which the holding company managers would analyse and use for preparing monthly accounts, including profit and loss. At the meetings, they would go through the sales and accounts in detail and discuss any particular issues with the site, with staff or any other aspect (e.g. site maintenance) which was needed, as well as focusing on ideas, which they could do to improve performance in the forthcoming months ahead. They would explore different seasonal events or promotions they could do to attract customers and leverage any local activities to increase sales. Sales focused on the numbers of coffees sold, which was seen as the main 'currency' for all of the coffee-shops. Each staff member would know what they had served each day and whether it was good or bad within the current market context (*Causation, expected return / predictive trends*). The roastery also used the same approach, working with the holding company. However, these were focused on retail and wholesale coffee sales and making plans in particular for wholesale orders, which could impact the

running of the business, as they were often large and gave them fulfilment issues as the roasters could only operate at specific capacities (*Causation, expected return / predictive trends*). The cycle-shop chain had similar performance review meetings with premises managers, but these were more informal by comparison. It appeared that during fieldwork, the repair and maintenance teams were constantly working at full capacity and were booked up for weeks ahead, which meant that their main issue was ensuring they worked to capacity and completed jobs as quickly as possible whilst maintaining a quality service. Their focus at the time was trying to upskill non-mechanic staff members to enable them to complete some of the simple (but often time-consuming) repair jobs, such as repairing punctures enabling the team to get through jobs faster and more cost-effectively (*Effectuation, bird in the hand*).

Improving efficiency and reducing costs played a role within these discussions, which tended to focus on the highest costs, which were generally staff related, so ideas as to how to manage processes more leanly (e.g. saving staff time) were high priority, particularly on 'back-room' activities (E.g. managing stock replenishment). Oliver (cycle-shops owner-manager) described that in this context, reducing pure 'costs' (e.g. costs of stock) was not really a focus, as it was seen as considerably more impactful from a profitability perspective to increase sales, vs. reducing costs, which is something that is also reflected in the literature (O'Regan et al., 2005). This was the reason why freeing up staff time from non-sales-related activities was so important, as they could then be deployed to focus on generating business (*Effectuation, bird in the hand*).

Energy management: All of the businesses described energy billing to be difficult and described 'bill shock' as something which had hit them before (EEF, 2013). As described above, the coffee-shop and roastery businesses were supported operationally by a central team within the holding company. This meant that all billing, including energy was managed by Cornelia, the holding company finance manager. The only time premises managers considered billing was when she phoned them to get meter readings, and they had to go into the various locations (e.g. cupboards under the stairs) to photograph them to send her supply readings. Discussing this with Cornelia revealed that it was always problematic for her at these times, both in terms of getting readings from the sites, and then uploading them into the systems of the various suppliers, which supplied each site with

gas or electricity. Each of the businesses described that they had had at times had no bills for a long time, followed up by huge bills sent to them, sometimes seemingly out of nowhere from suppliers, and this had caused cash-flow problems in the past. Each premises had different arrangements and suppliers, which was also reflected in the cycle-shop chain. In fact, two sites across the businesses included in the study were not currently paying bills. The cycle-shop's first original premises had had problems identifying a MPAN number for billing purposes, and for that reason had never paid bills since they had moved in nearly ten years previously. Oliver had contacted their supplier on several occasions to try and rectify the issue, but due to a lack of interest from the supplier, they had basically given up, but he still felt uncomfortable that they had not paid bills for several years (*Absence of Strategy, no control*). A lack of time to manage and resolve the issues were the reasons described why they did not try to get a better handle on things. Furthermore, Cornelia said it was tough to get each of their premises onto the same supplier and it probably wouldn't work as subsidiary businesses were differently owned, so there wasn't really that good a reason to try and bring them all together. She also described that it was challenging to work with energy suppliers, who also seemed to have a very ' hands-off' relationship with customers – they had therefore decided to manage these situations reactively, as the bills were not large enough to warrant trying to proactively sort out (*Absence of Strategy, putting out fires*).

On-site, energy management was considered from time to time by premises managers, such as turning off equipment when it was not in use. However, from the time I spent on site and from discussing with premises managers, the opportunities for this to occur (within opening hours) seemed limited; constrained by issues such as needing to be 'ready' to service demand instantly when customers came in, as described previously in section 5.2.4.2.

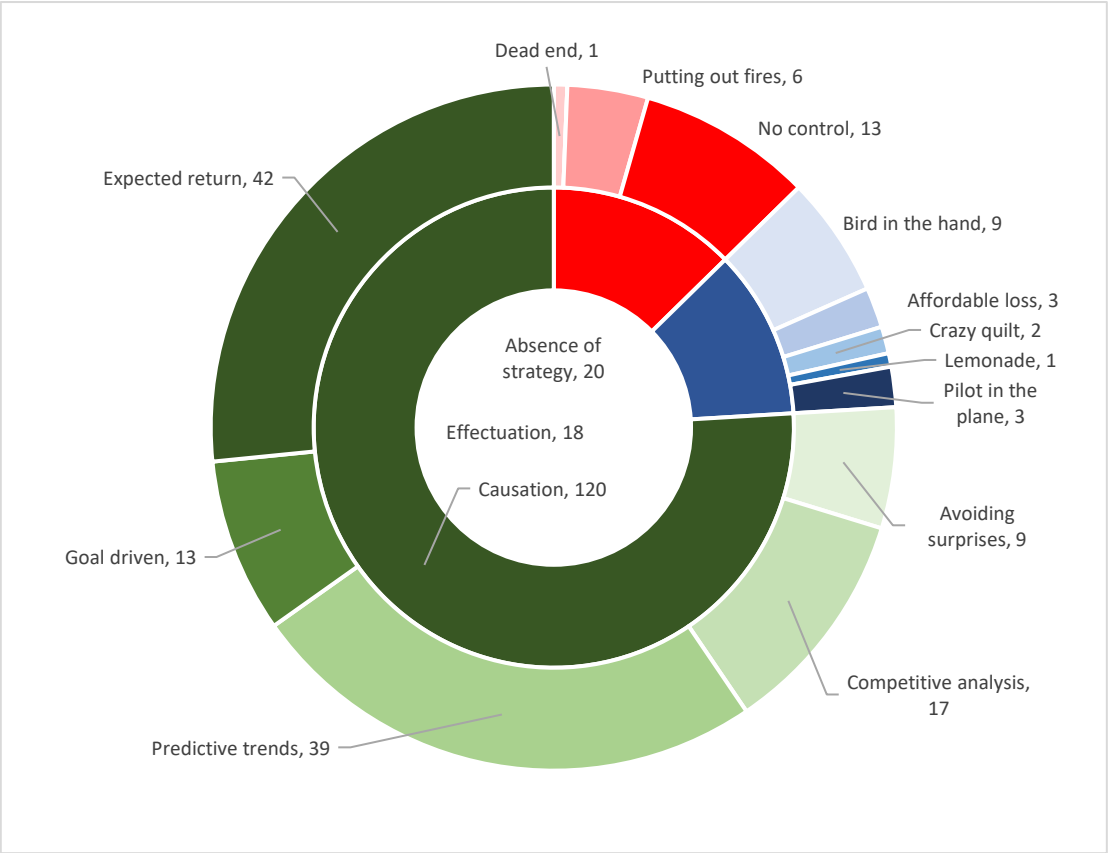
Considering equipment energy efficiency upon replacement (i.e. when equipment failed) did not come up as an issue they considered, and this appeared to play little role compared to other concerns, such as quality and durability which were considered very important. Mara (SW coffee-shop owner-manager) described all of the on-site equipment had a 'very hard life', so they carefully chose replacement equipment to ensure they would last and could cope with constant use and abuse.

From an entrepreneurial behaviour perspective, Causation and Effectuation behaviours both played a role. However, in some areas, and explicitly energy management demonstrated several elements of Absence of Strategy, discussed further below.

5.2.4.4 Applying Hauser's entrepreneurialism lens to the findings

Applying Hauser's Causation, Effectuation and Absence of Strategy framework to the findings overall shows that Causal decision-making dominated current management practices. Effectuation is also apparent, and it appears to play an increased role in areas where management practices are more challenging or where they have a more substantive influence on business performance, such as in people management. This aligns with existing literature, which describes that Causation tends to dominate in decision contexts involving maintenance of existing service (or artifacts) (Smolka et al., 2016, Vershinina et al., 2017, Hauser et al., 2020).

Figure 40: Patterns in the context of premises and staff management: Causation, Effectuation and Absence of Strategy (Hauser et al., 2020) [85]



Interestingly, energy management activities played a considerable role within coding relating to Absence of Strategy (Figure 40). As described above (section 5.2.4.3), energy management issues related to billing problems, challenging metering arrangements[86], having different suppliers across premises and very remote and sometimes difficult relationships with suppliers. Energy management often 'fell through the gaps' because of its low overall cost relative to overall running costs, and their inability to do much about it, as they did not feel they had access to helpful systems which enabled them to manage energy better. These issues broadly reflect findings in the literature (Trianni and Cagno, 2012). However, looking at this from an entrepreneurialism perspective, within the broader context of other business decisions, helps better understand how and why these challenges manifest themselves relatedly. It also helps to inform ways in which opportunities to help

[85] Chart numbers refer to the number of instances where the observed behaviour was coded within this area of inquiry in the data.

[86] Including difficulties accessing meters to take readings and problems understanding accurately which meters related to which premises (or areas of premises).

improve energy management in helpful ways, which is the focus of the second inquiry cycle (section 5.3). At the end of this inquiry cycle, I introduced the GlowPro prototype to participants and their reactions to it are described in the next section.

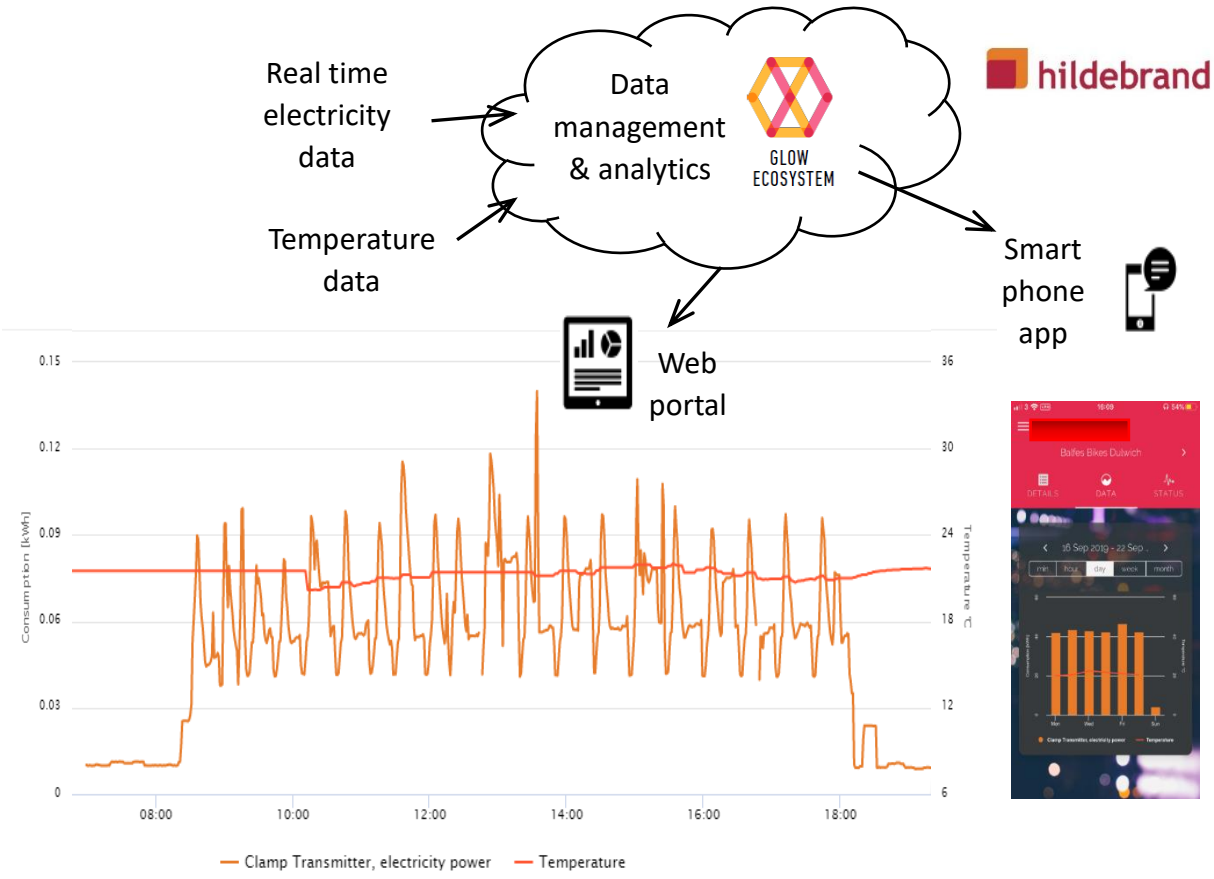
5.2.5 Reactions to GlowPro prototype

This section describes findings relating to participants' reactions to and use of the GlowPro prototype system, explored with business owner-managers, premises managers and the holding company finance manager for the coffee-shop and roastery businesses. As a reminder, I installed the GlowPro monitoring kit at one or more of the businesses' premises during my initial site visits, which enabled me to monitor their electricity consumption and internal temperatures (see Table 5 for details). I experienced data quality issues with the GlowPro prototype at each of the sites (similar to that experienced by Hildebrand[87]) and I wasn't sure for some of the interviews whether it was going to be easy or not to log into the system live through the web-portal. So before each interview, I reviewed a site's data in detail and printed off some excerpts of the system in the form of paper hand-outs, which I could then use as prompts within the discussion. Figure 41 provides an example of one of the read-outs of electricity consumption and temperature at one of the cycle-shops during a typical working day, as well as an overview of how the GlowPro system worked within the web portal and smartphone app outputs.

Finally, I also wanted to see whether they would use the system themselves between my visits, so I was also able to provide them with a live login to the system so that they could access their data if they wanted. I shared these with each participant in case they wanted to use the data for any existing activities.

[87] See Table 4, Absence of Strategy, putting out fires code group.

Figure 41: GlowPro prototype overview and example data outputs; electricity consumption (kWh) and temperature data (°C) across a day in the cycle-shop.



Without exception, all participants gave a generally lukewarm reception to the system in its current form, and none of them tried to log into the system to use it for any business activities in the subsequent months.

I can't think of a situation where I would rely on it too much. So I probably wouldn't pay for it, but if I had it, it would be interesting to go on, as it's data, isn't it? (Oliver, cycle shop owner-manager)

I trod carefully around this aspect, mainly because, given previous discussions we had about energy management (section 5.2.4.3) I had not had very high expectations around their level of use of the system. The prototype was basic as it only really showed electricity consumption and didn't do anything much further than this. I, therefore, prepared for this part of the discussion and made sure that I communicated that I was not disappointed if they had not used it, and that it was just as interesting to know and discuss ways in which it

would not be helpful as areas where it was (which is explored further in the second inquiry cycle, section Cycle 2 - exploring broader users for smart meter and other data).

Cornelia, (finance manager, coffee-shops and Roastery) pointed out that the data was not useful at all from her perspective because the system was not currently linked directly to energy suppliers or gave actual meter readings so it would not help her save time in managing billing, or reducing the likelihood of bill shock. She suggested that it would be helpful if the system were directly connected to billing. This was similar to the reaction of those interested in GlowPro within the shopping centre context (Chapter 4, section 4.2.2.1); however, she also pointed out that this would be difficult because different premises had different suppliers, and it would not help her very much if it were tied to suppliers directly, as she would have multiple systems to log in to. We then discussed that, should the system be able to link directly to meter readings, this could be some sort of independently managed subscription service, which was interesting. However, I also knew that this might not be useful in practice, as this would require smart meters, which would then effectively remove the need for manual meter readings, and therefore this need overall.

Premises managers were somewhat interested in the data, from the perspective of enabling them to understand and attempt to visualise through the data, activities and processes which were going on on-site at different times (discussed further in section 5.3.1). However, on two occasions this conversation quickly morphed into uncovering the lack of disaggregation of the data by appliance, or appliance type (e.g. cold-storage energy use, HVAC systems, lighting etc.), which was seen as being more useful, as I found with Hildebrand previously (Chapter 4, section 4.2.2.2).

So, have you, or are you going to develop something which associates behaviours with this? So you could have a tick boxes where you know where certain things would relate to say lighting, aircon, kettle etc. and you would be able to set that within it, so you could report that? (Oliver, Cycle-shop owner/manager).

Interestingly, some of the owner-managers started to make creative suggestions as to how the system could be improved to make it more relevant to them. For example, Josephine (London coffee-shops owner-manager) immediately suggested that premises temperature alerts might be helpful to alert staff early in the day if it was likely to be very hot later in the

day, which could help on-site staff open up windows to increase ventilation earlier to mitigate overheating. These spontaneous suggestions helped inform the development of the second inquiry cycle, involving exploring potential uses for smart meter and other data in greater depth, discussed below.

5.2.6 Cycle 1 summary and reflections

In this inquiry-cycle, SME participants had shown themselves to behave entrepreneurially according to the definition of entrepreneurialism (section 2.7.3). They also clearly exhibited entrepreneurial traits aligning with Causation and Effectuation heuristics as described by Sarasvathy (2001b). They had developed and grown their businesses, broadly working towards long term Causal goals but which were achieved through principally Effectual actions. Their businesses were generally now well-established, and they were managing their premises and staff in a principally Causal manner (Sarasvathy, 2001a, Read and Sarasvathy, 2005, Berends et al., 2014a).

In line with the literature, it appeared that owner-managers could utilise and readily switch between different entrepreneurial decision-making approaches depending on different prevailing decision contexts (Nummela et al., 2014, Smolka et al., 2016, Vershinina et al., 2017). As their businesses had grown, the activities of the businesses overall graduated towards more Causal decision-making approaches, as they learned more about their markets and how to succeed within them. This appeared to correlate with a narrowing their scope of activities and focusing on honing those which were successful as they developed their respective 'niches'. In particular Causal decision-making appeared to dominate within aspects of their businesses which involved management of premises and production processes (section 5.2.4), which were areas over which they could exert considerable control. However, Effectual decision-making appeared to dominate when exploring the further development and growth of the business, especially when seeking to expand into and exploit new market opportunities, something which the roastery and coffee-shops businesses were particularly focused on (see section 5.2.2).

The introduction of GlowPro to owner-managers, premises managers and the coffee-shop/roastery finance manager invoked mixed reactions (section 5.2.5). Interest in the system focused around Causal decision-making themes, for example further enabling them

to improve their management of premises and sites. However, participants quickly lost interest in the data in its current form, and identified limitations including its lack of potential to improve billing activities, and lack of ability to disaggregate between different sets of equipment on site, which in their eyes severely limited its utility from a management perspective.

The following section describes the second cycle of inquiry, which focuses on exploring whether and how participants might be able to use smart meter and other data in a broader sense, now that GlowPro had enabled them to see the data in its raw form.

5.3 Cycle 2 - exploring broader users for smart meter and other data

This section describes findings from the second inquiry cycle with SME owner-managers and premises managers across each business. It includes findings from the interviews, reflections on progress with the fieldwork and how these influenced the direction and focus of my interactions with them.

In this cycle, at the start of the follow-up discussions, I explicitly acknowledged what I had heard previously. This involved relaying back their concerns that GlowPro in its current form was not particularly helpful, and that now I was interested in areas where the data, likely in combination with other data and systems might be useful to them. My goal was to explicitly share the issue and have open explorations with them about what might be helpful, why, and what would not; thereby explicitly asking them to help inform solutions. Then, depending on where we got to with the discussions, I hoped this would enable further exploration of how such data might be useful for them in practice, building on what I already knew about how they managed their premises. Throughout this, I used the Hauser entrepreneurialism framework as a basis for the exploration (Hauser et al., 2020). Within this approach, I took some of the lessons from the open and broad Hildebrand approach of fully putting yourself 'in their shoes' (section 4.3) – but approaching it a bit differently, by building upon previous knowledge I had gathered. Firstly, I had already had a good understanding about how they managed their businesses and the challenges of that, which we could draw from and build on. Secondly, the discussions were about to focus more explicitly on smart meter data as we had the data in front of us (I used print-outs of premises monitoring data as stimulus materials) and were discussing tangible, context-specific issues. Thirdly, working with Hildebrand in part 1 and the SMEs during the first inquiry-cycle of part 2 had informed a number of possible smart meter and other data uses, which I used as discussion prompts.

From an AR perspective, this inquiry cycle was more participatory because it did not involve presenting solutions (e.g. GlowPro), but opened up discussions as to how smart meter (and other) data could be used in ways, which would be helpful, both to improve management of energy and other operational issues.

The following sections summarise the findings. They are structured around issues including staff and operational management (section 5.3.1), health and safety and management of the internal environment (section 5.3.2), marketing (section 5.3.3) and energy management (section 5.3.4). The next sub-section (5.3.5) then explores how potential use-cases that had been identified could be integrated into current management systems. The final section (5.4) then summarises how these areas relate to Hauser et al.'s framework, describing areas which fit within the framework and other aspects which did less so. This includes delineating between the process of exploring smart meter and other data, and the ultimate goals of these activities.

5.3.1 Staff and operational management

Building on previous discussions looking at the GlowPro electricity consumption data (Figure 41), we explored potential implications of the ability to identify who was likely to be on site, when and what was happening on-site, on the basis that this could potentially be useful in a staff management context (*Effectuation, bird in the hand*).

"*That will be [… staff member] turning up first thing in the morning* [in response to looking at a daytime electricity-use handout, focusing on an electricity use spike at approximately 7.15am] ." (Mara, SW coffee-shop owner-manager)

From a staff presence perspective, for Oliver (cycle shop owner-manager), this was a dead end (*Absence of Strategy, dead end*) because he already got alerts from his security systems which alerted him on his smartphone when the shops were opened in the morning and closed at night. Furthermore as fewer energy-using activities were going on on-site at the cycle shops, the data was not otherwise that useful. For Josephine and Mickey (London coffee-shop owner-manager and premises manager); however, this was of interest as it could help alert them as to when they had opened late or turned on the boilers late, which had a quality impact on coffee served (*Effectuation, bird in the hand*).

"That is useful to know. As you know a) someone has turned up to open, and b) they have opened properly. That's really useful… Seeing the data helps me see whether the coffee machines were turned on in time, so I know whether good quality coffee is being served in time for opening" (Josephine, London coffee-shop owner/manager)

However, there were reservations about using the data in practice as Mickey worried about the impact on trust in their staff, and their sense of responsibility or agency in managing the shops.

"From a management side, it might also end up being micro-management and staff might not react well…. You know it's quite tricky as you would have managers in those locations where you could kind of expect them to be on time and trust them to be on board, so culturally to affect that – you work with the atmosphere and the relationship you have with them." (Mickey, London coffee-shop premises manager)

However, the discussion revealed alternative ways in which the data could be used more helpfully, fitting in with their pre-existing (trust-based) management context. First, as staff-management was a known and openly discussed issue in the London coffee-shops, Mickey thought it might be enabling or empowering to make the data available to premises managers to support their own management activities. They wouldn't likely use the data, from a day-to-day perspective as that would have similar trust implications in the relationships they had with their staff. Instead, it could be used to analyse the number of days within a month that they had opened later than planned, or had issues which could support the identification of ways in which they might be able to better manage the premises over time. Mickey felt that it might be empowering to give ownership of the data to premises managers who could bring any analysis they wished to monthly performance meetings (section 5.2.4.3), evidencing issues, which they could then work with owner-managers to solve problems, such as making a case for additional staff recruitment. To achieve this, the raw data would probably not be a useful input. However, logging of time-stamps, derived from the energy data which identified dates they opened late (or shut early) might be helpful. Finally, looking at it more broadly, it was also suggested that such data could be combined with timed sales data (*Effectuation, lemonade*) to understand what impacts this may have had on sales and profitability over time.

5.3.2 Health and safety and management of the internal environment

Previously refrigeration temperature logging had been identified as a potential use case (Chapter 4, section 4.2.2.2). Both Mickey (London coffee-shop premises manager) and Mara (SW coffee-shop owner/manager) thought this was an excellent idea as it could help them identify, through alerts if there was a potential issue with refrigeration, as well as

automatically logging records, needed twice per day for the Food Standards Agency. Local Authority representatives could inspect premises at any time, so this was a high priority and currently took up staff time as they were done manually (Figure 42). They were also prone to be forgotten, which was a risk so both said they would be willing to pay for a subscription service to do this potentially.

Figure 42: Example Fridge/Cold Room/Display Chill Temperature Records (Food Standards Agency, 2007).

SC2 - Fridge/Cold Room/Display Chill Temperature Records

Month: June Year: 2007

Temperature Of Fridge/Cold Room/Display Chill* (Insert Name Or Number Of Units In Shaded Boxes Below)														
Unit													Comments/Action	Sign
Date	AM	†PM	AM	†PM	AM	†PM	AM	†PM	AM	†PM	AM	†PM		
1st	3°C	10°C 7°C											Gauge adjusted (Re-checked 1 hr later)	A Jones
2nd														
3rd														

Temperature of food must not exceed 8°C. *Some businesses may wish to record freezer temperatures. †It is recommended that fridge temperatures are checked at least once per day. Some businesses may wish to check fridges more frequently.

Manager/Supervisor check on	8 / 06 / 07	/ /	/ /	/ /	/ /
Sign	EC				

Mickey was aware that a smartphone App had recently become available to do similar tasks, although these were designed to support hospitality checklists to improve team productivity, to his knowledge, this had not had logged temperature data integrated into it yet.

Furthermore, following on from previous suggestions made by Josephine (London coffee-shop owner-manager, section 5.2.5), she suggested that if the system could also include weather-related data and produce alerts to help them predict and manage extreme weather events better that would also be helpful (*Effectuation, lemonade*).

5.3.3 Marketing

Together, these discussions explored whether making energy use data visible and available could have marketing benefits. Mike, the roastery premises manager could see that his could benefit them, as on the wholesale supply-side of the business they were starting to be asked to evidence environmental policies and procedures as part of their contracts. Whilst

they knew their gas consumption already through their roasting management system, the electricity data would also be helpful as that could add a broader understanding of their impacts, which could be interpreted and reported within these policies although they felt this would require expert support to enable them to analyse the data appropriately for this purpose (*Effectuation, lemonade*). He thought that this could be an additional service provided by their roasting management system developers, Cropster (Cropster, 2022).

For the coffee-shops, the idea of reporting their energy use per cup of coffee, was new to them and of some interest, however Mickey (London premises manager) described that this was not yet within the sphere of influence of their sustainability focus on coffee. This focused on the ethical and sustainable sourcing of coffee (e.g. fair-trade) and the recyclability of coffee cups, which had become highlighted as problematic in the press (BBC News, 2018).

Coffee and its energy use was not currently on the radar; however, he was interested in exploring it as it might become an issue in the future. If they could demonstrate some progress in this area by reporting on their energy use per coffee, it might be something to help them demonstrate leadership which would have a positive brand aspect. However, it was a bit hard to conceptualise what this might look like without some sort of data output to look at. He thought it would be good to start by reporting energy per cup of coffee within management data first (section 5.3.1), which might spark ideas from there.

5.3.4 Energy management

Billing

The concept that GlowPro could be a source of billing information and remove the need for gathering premises meter readings to pay bills was attractive to Cornelia, the finance manager, which she had previously described as painful and time-consuming to do (section 5.2.4.3).

"*It would be most useful if the system could provide up-to-date meter readings across all sites… As we have lots of different suppliers across the different sites, it would be useful to have all of this data in one place*" (Cornelia, finance manager, coffee-shops and roastery)

She also mentioned that it was important for her that a system like GlowPro would be useful to use across different sites, but that it would also be necessary to be independent of

individual energy suppliers. This was pragmatic, as they had multiple suppliers for different premises and did not trust suppliers, so they would be reticent to integrate systems more closely with them than they currently did (*Effectuation, lemonade*).

Whilst she was not as interested in the data in-of-itself, she could see that it would be helpful for different parts of the business to have the data, if they could integrate it within other existing systems. This included understanding the energy used per roasting cycle at the roastery, as this used considerable amounts of energy (mainly gas, which was not monitored by GlowPro), and it would be useful to be able to analyse this data to see if there were ways in which efficiencies could be improved here. Mike, the roastery premises manager, was also interested in the data from two perspectives, first of all in terms of identifying potential energy wastage from equipment being left on, for example, out of hours when there were no production runs being delivered. Secondly, he thought that the information might also be helpful from a management perspective, in particular to help communicate what is going on with the business and how it related to productivity overall.

"One thing I noticed when I got here was that what people perceive as happening in here can be quite different to reality. So communicating rise in production is putting a strain on these areas. When you are forecasting for example you could say oh we want to hit these targets, but then if you don't hit them. You might almost feel like people should have time, but in order to hit those targets you probably need to be communicating how busy the business actually is here. As here we are focused on growing that's one thing, if we were a business focusing on consolidating, were at a different part of that curve at the moment." (Mike, roastery premises manager).

From an energy management perspective, if the data were integrated into existing management systems, this could be translated into relevant metrics, such as energy used 'per coffee or food item' costs, and then see whether differences in approach could influence this. However, it would involve transferring energy data into other systems, which is discussed further below (section 5.3.5).

Equipment management and performance

Mike also thought that if energy-related data were integrated into such a system, it could provide further benefits such as to help identify wastage, and potential poor performance of

equipment in addition to temperature checks. It could also provide some basic guidance and advice on what to do to help if equipment goes wrong. In the same vein, Mickey (London coffee-shop premises manager) was also interested in this, as there are linked energy and health and safety issues here, and sometimes advice and guidance was needed for staff to rectify issues.

"[describing a situation where a refrigerator was not working properly] *That could be to do a defrost cycle and then try and get another reading. Um… there would be fans which could get clogged with dust which would affect it, and certain things or approaches to make sure those temperatures were down."* (Mickey, London coffee-shop premises manager)

5.3.5 Integrating smart meter data into existing management systems

The discussions I had had with premises managers and owner-managers had also revealed some additional reasons why energy, in terms of its direct management is given such little attention through the exploration of smart meter data. Whilst they tended to use very basic approaches for managing energy, they had access to, and extensively used, dedicated and sophisticated management systems which were geared towards helping them with operational management.

Josephine (London coffee-shop owner/manager), upon exploring smart meter data quickly identified that whilst the data in of itself was not that interesting, it was likely to be helpful if it were integrated into these other operational management systems. For her, it was in essence the lack of access to this data, and ability to easily integrate it into other systems which prevented it being used actively. Building on the marketing concept of understanding the energy demand per cup of coffee (or kg of roasted coffee beans) (section 5.3.3), she identified that this would be something straightforward to do if this data were integrated into their existing operational systems. There were two potential opportunities for this, each with different focuses and which could benefit the business in different ways. Firstly, the data could be integrated into café/restaurant management software or point of sale (POS) systems, such as SquareUp, see Figure 43 (SquareUp, 2022), which was used in the coffee-shops for day-to-day management purposes. As described above, the raw data probably was not that useful, but it could inform alerts around temperatures, such as identifying fridge temperature issues or whether it would be hot or cold. Secondly, it could also include alerts and advice to improve energy management, so that if the system itself

could identify that it was quiet – to give alerts for staff to go around looking for things which could be turned off. This was also the place where out-of-hours alerts, such as if there was a power cut would be useful to include. The reason for these suggestions was that these systems were being used all the time by premises managers and other staff, and they understand the systems well and look at them constantly throughout the day. Integrating such alerts would be helpful as a way to get their attention in a way that was not possible through using a separate specific energy management system.

Figure 43: SquareUp Point of Sale (POS) system (SquareUp, 2022)

Josephine had previously had significant dealings with the SquareUp team and felt that this wasn't currently on their radar, but they would be quite likely to be interested in this as they were constantly looking for new ways to improve the value that their systems added. She got quite excited by the idea and spent some time trying to introduce me to her contacts in SquareUp with the idea that we could go and talk to them and pitch the idea as a value-added service (*Effectuation, crazy quilt*).

One of the reasons she also thought it would be interesting to them was because of their current model of service provision. Considering that monitoring kits and hardware (e.g. for temperature monitoring) would be needed, this aligned with their current business model of providing POS hardware. She also thought that, for energy-intensive sites with lots of equipment (e.g. restaurants), it would be interesting to explore the idea of adding in sub-metering kit, which would help them disaggregate their energy demand, and help them identify automatically if there were any issues, such as refrigeration equipment going faulty.

"The other thing which is interesting to SquareUp. Is that they are already supplying bits of kit [such as card machines and till displays]*, so the idea of them supplying plug based kit, isn't crazy to them." (Josephine, London coffee-shop owner-manager)*

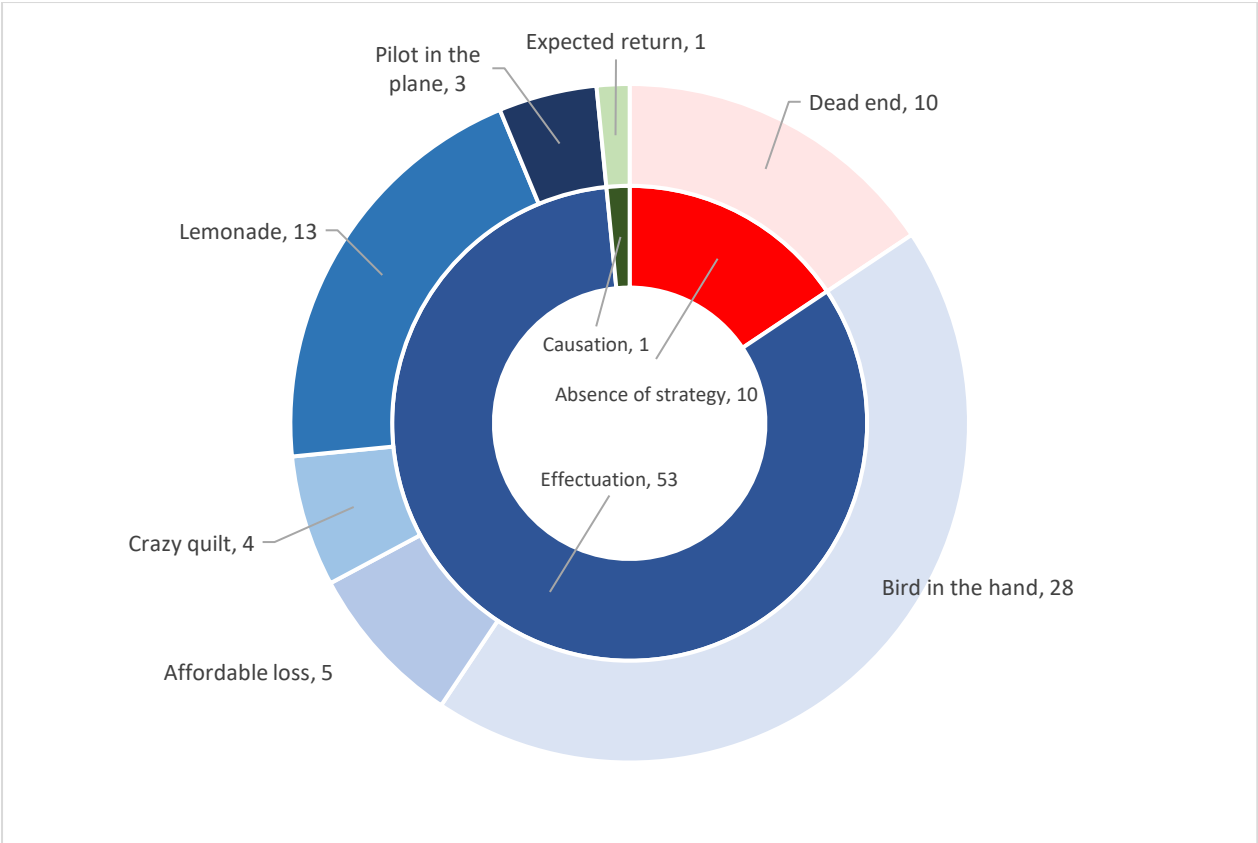
The second approach to integrating energy data into existing systems was to link it up directly to their accountancy systems. Each of the businesses used some accountancy software linked to POS and other systems to help them understand and manage their turnover, cash flow and profitability over time.

Cornelia (coffee-shops and roastery finance manager) was not overly interested in energy management data, but she described that integrating data into this system would help analysis to turn energy data from what was currently seen as a fixed cost, into metrics, which make sense from a performance perspective and can therefore be better managed. This might also support their marketing interest in reporting energy and CO_2 emissions, as this tended to be the system they used to extract data needed for tender bids or wholesale contracts. After exploring this aspect in some detail; however, it was thought that it might be better to integrate the data into POS software, as this data was automatically linked up to varying degrees to their accountancy software, so it might already get included if it became an input there.

5.4 Applying Hauser's entrepreneurialism lens to the findings

The sections above show how SME owner-managers and premises managers engaged in a series of detailed, creative explorations of how smart meter and other data could be helpfully used. As described above, these ranged across several operational and performance-related areas, as well as energy management. Across these discussions, coding and analysing the data, again using Hauser's framework (Hauser et al., 2020), showed engagement in, and use of, mainly Effectual decision-making approaches as shown in Figure 44.

Figure 44: Patterns within the exploration of smart meter and other data processes: Causation, Effectuation, Absence of strategy (Hauser et al., 2020) [88]



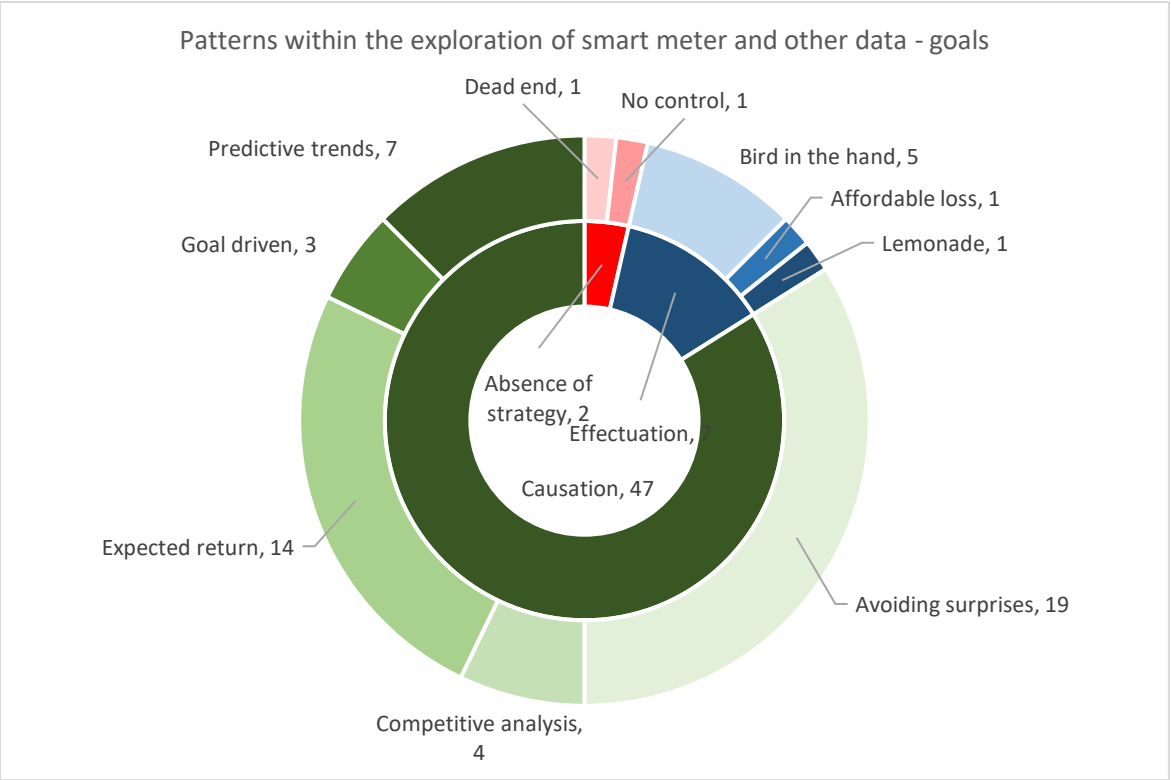
These approaches appeared to align closely with the approaches they take when strategically developing their businesses (inquiry cycle-1, section 5.2.6), thereby showing that very similar approaches are relevant for exploring how external interventions are conceptualised as those which are for internally evolving and growing their businesses

[88] Chart numbers refer to the number of instances where the observed behaviour was coded within this area of inquiry in the data.

(Hauser et al., 2020). While exploring these ideas in discussion with the owner-managers and premises managers, some were subsequently written off as dead ends as we identified issues and constraints that would prevent them from being useful. It is likely that more of the ideas might well be dropped too if they were possible to explore further past simple concepts, but as several of the ideas seemed genuinely useful (to the extent some were things they said they would be willing to pay for) it is likely that some of them likely have some real potential to help them.

That said, whilst Effectual thinking dominated how they conceptualised and identified and discussed smart meter and other data-based opportunities when considering the goals of these explorations, most of these were driven by goals of enabling greater Causality in which they are able to manage their operations and premises. For example, Josephine (London coffee-shop owner/manager) identified through looking at the data and thinking laterally that it could be used to manage staff (*Effectuation, bird in the hand*). The thought process led towards better enabling them to manage staff more effectively to help improve their effective management of the cafes (*Causation, avoiding surprises / goal driven*). This led to further coding and analysis of the data to look at the goals that underpinned the explorations, which overall showed this was indeed dominated by Causation (Figure 45).

Figure 45: Patterns within the exploration of smart meter and other data – goals: Causation, Effectuation, Absence of strategy (Hauser et al., 2020) [89]



The analysis helps to show, via the means of a smart meter data based intervention, how entrepreneurs strategically approach whether and how influences on their business can be integrated into their businesses. Broadening the discussions with the participants revealed that overall they continually felt that they have to be creative and evolve to further the success of their businesses, taking advantage of or warding off lots of different factors in the market, which could help or hinder them along the way. Whilst this was a constant challenge, this was not seen as particularly stressful or problematic for any of the owner-managers, more they thrived on it and said this was a big factor in what drove them to run their businesses in the first place. For example, Oliver (cycle-shop owner-manager) said that whilst this constantly stressed him out in the early days of the business, he now enjoyed the challenge of it and wanted to use his experiences to build and further grow the business.

Finally, when operating, as many SMEs are, within a constant state of 'flux' and uncertain contexts, this exploration helped to reveal the different approaches they use to help them

[89] Chart numbers refer to the number of instances where the observed behaviour was coded within this area of inquiry in the data.

be more in control of the things they can control, and also seek to take advantage of new opportunities when they come along.

5.5 Reflections

After having some concerns after the first cycle of inquiry due to the lack of interest in the GlowPro prototype (section 5.2.5), I was pleased with the way in which the second inquiry cycle had gone. Sharing the problem with participants and exploring explicitly using an approach which explored and leveraged entrepreneurial frameworks I felt had been successful in tapping into ideas where smart meter and other data could be used in ways which were genuinely useful to the businesses. The fact that one of my participants had gotten sufficiently interested to explore potential ways to develop the idea of integrating this into their POS system, was exciting. It felt especially given the broader context in the literature that described SMEs as be very hard to engage with, let alone get them to embrace energy demand interventions in a meaningful way.

In this way, the Action Research approach felt like it had been a genuinely helpful way of breaking through research barriers, thereby helping me to get involved in understanding how to influence SMEs. Coming away from the experience, I felt that it is hard to conceptualise alternative research methods that would achieve similar goals.

Whilst the AR approach had been hard to do in practice, in retrospect I was glad of the experience of learning from the cycles of inquiry. I felt I had learned the value of keeping an open mind within the research. It also helped demonstrate the benefits of fully immersing yourself in your participants businesses and challenges. Putting your own agenda to the back of your mind can reveal solutions you hadn't anticipated and may well not otherwise consider. This had genuinely been a voyage of discovery and I had ended up in a different place from what I had imagined, but felt much the better for it.

5.6 Summary

The final cycle of inquiry involved opening up the issue of how to intervene with smart meter and other data in ways which would help my participant businesses. The exploration and discussions, having the advantage of being able to leverage and build upon several months of engagement, site visits and getting to know the participants and their businesses well, helped uncover and explore in some depth potential opportunities, some of which appeared to have real chance of success if they were further developed. The exploration also revealed much about how SME entrepreneurs think about and act in the context of an

outside intervention, which is seeking to influence their activities. This helps develop understanding about how other interventions are likely to be considered, and informs insights about how one could approach developing interventions in ways to enable engagement by owner managed SMEs. This is further discussed in the next chapter.

6 Discussion

6.1 Introduction

This PhD set out to answer the research question: **How do owner-managed SMEs respond to the development and testing of new smart meter data-based energy management tools?**

At the contextual-level of inquiry the research question was supported by the following research objectives:

1. RO1: Informing the design and deployment of GlowPro energy management tools.
2. RO2: Improving understanding of how energy management can be improved to reduce energy demand.
3. RO3: Informing understanding about what other benefits (e.g. co-benefits) smart meter data-based energy management tools may deliver, or indeed whether it might be better to consider energy management as a co-benefit of other, higher priority actions.

At the meta-level of inquiry, the research question was supported by this further research objective:

4. RO4: Contributing to understanding about applying an action research approach in this context, learning about its strengths and weaknesses and developing recommendations for future work.

These questions were set in the context of limited existing research about SME energy management and that this is an intractable issue with many different ways the problem can be conceptualised, as described in the literature review chapter. Within this context, a clear evidence gap pertains to better understanding how SMEs make decisions and how this relates to energy management, which is important given that energy underpins a large proportion of organisational activities. In addition, there is also a more pragmatic evidence gap, which pertains to how SMEs respond to energy management interventions.

Outside of energy management, there is a discipline of business management research, which focuses on SME management and entrepreneurship (Sarasvathy, 2001a, Sarasvathy and Dew, 2005). This discipline seeks to explore the goals and activities of owner-managed SMEs to help understand how and why they achieve success (or failure). This discipline has not been connected with SME energy management research previously.

The PhD research question and objectives were also developed within the context of an opportunity to get involved in an innovation project led by Hildebrand Technology Ltd to develop new smart meter data-based energy management tools aimed at SMEs using an Action Research (AR) approach. The project enabled the exploration of the research question in two ways. Firstly, working directly with Hildebrand to inform the development of an energy management tool prototype called GlowPro (Chapter 4, findings part 1), and secondly, testing the system and exploring smart meter and other data uses with a sample of owner-managed SMEs (Chapter 5, findings part 2). The aim of the Government-funded innovation competition was to develop tools to improve energy management in SMEs, ultimately helping to reduce or improve the efficiency of energy demand.

The rest of this chapter describes how this PhD has helped answer the research question and objectives and its contribution to academia, policy and industry. The chapter commences with a brief over-arching summary of the findings followed by discussion of them and how they have answered the research question and objectives.

6.2 Findings summary

The first part of the project (Findings part 1, Chapter 4) involved AR working with Hildebrand to develop GlowPro, as smart meter data-based energy management tool. The project involved developing tools within the retail and hospitality sectors, within two contexts a) shopping centres and b) owner-managed SMEs. In responding to the NDSEMIC Competition brief, Hildebrand focused on the lack of attention barrier associated with energy management and responded to this by exploring how to increase the utility of GlowPro by broadening its focus to support other operational activities. To do this, the team undertook research with several potential tool users and broadly explored their operational contexts and challenges, with only limited explicit focus on energy management. In taking this approach, new potential uses for smart meter and other data were discovered, for example supporting security management and health and safety applications. Due to a range of factors, including lack of roll-out of ND smart meters (Department for Business Energy and Industrial Strategy, 2020c) and also complexities associated with rolling out the tool within complex ecosystems like shopping centres, the prototype tool itself did not directly lead to a successful commercial venture. However, the team discovered a range of other opportunities during this time, including a smart meter tariff comparison tool (Figure 35),

and a new hardware solution (Figure 36) to disaggregate energy demand across different uses which were developed subsequent to finishing the Competition project.

Hildebrand took an entrepreneurial approach during the Competition and in doing so deviated from activities that Competition managers might have expected in some ways. For example, the choice of shopping centres as a focus and broadening the focus of the GlowPro tool into non energy management activities to help overcome engagement challenges due to lack of interest (Revell and Blackburn, 2007, Trianni and Cagno, 2012). This, also led to the identification of the entrepreneurship theories of Causation and Effectuation, as developed by Sarasvarthy (Sarasvathy, 2001a) as a lens for understanding development of new energy management tools.

Part 2 of the project (Chapter 5) involved testing the GlowPro prototype developed in part 1 to test it with three owner-managed SMEs in retail, hospitality and small industry. Employing lessons learned from part 1, this involved a broad exploration of smart meter and other data and its potential uses and exploring entrepreneurialism concepts in greater depth. This demonstrated that these SMEs made decisions in entrepreneurial ways. For example, Effectual decision-making dominated how they developed their businesses into their current guises. Energy management, as found elsewhere in the literature is a rare activity that often aligns with another entrepreneurial decision-making heuristic, Absence of Strategy.

How the SMEs responded to new outside influences, such as a new energy management tool (e.g. GlowPro) aligned mainly with Effectuation (see Figure 44). For example, once they understood the premise of the opportunity, they thought creatively about different ways it could be used within their business, relating to improving energy management and more broadly.

Whilst Effectuation dominated these discussions, it was notable that decision-making concerning activities where smart meter data becomes relevant centred around maintaining existing products and services (artifacts), and these were dominated by Causation (see Figure 45). This was because they were focused on areas where they had considerable control and wished to increase that further where possible.

These activities helped to identify that energy management suffers from a lack of attention, not only because it only warrants limited interest within the context of other business priorities, but also because current systems they need to engage with (e.g. energy supplier billing portals) are separate from other management systems and hard to engage with. The findings also help identify further broad uses for smart meter and other data, including quality management and staff activity management, although the context surrounding each opportunity varied across the businesses, and so would need to be subject to individual contextual tailoring to work for them.

The findings suggested that integrating smart meter and other data into existing systems the SMEs commonly used to manage their operations, such as point of sale, or accountancy systems would be helpful, as opposed to the alternative of developing an energy management proprietary system. This would enable them to integrate smart meter data into these existing systems, enabling them to have greater potential to use it, in ways which integrate with other operational systems. This would enable its analysis with operational data (e.g. sales data) to develop metrics of greater relevance (e.g. energy used per cup of coffee served). This, alongside other benefits of the smart meter roll-out (i.e. lack of meter readings and estimates), should help reduce Absence of Strategy seen in this area currently.

Rather than focus energy management activities on the cost saving benefits they might bring, leveraging SMEs desire for greater operational control is likely to be more engaging and helpful. This should enable them to be more productive with their energy use, which aligns better than energy demand reduction, which tends to be the goal of energy policy makers. Finally, it appears that because of SME owner-managers effectual decision-making tendencies, it is worthwhile considering how they can have agency to consider how they use the data in specific ways which benefit them.

Next section discusses the research question and each research objective in turn and how the thesis answers each of them.

6.3 How did SMEs respond to the development and testing of new smart-meter data based energy management tools?

6.3.1 Response to GlowPro prototype

In terms of the basic prototype that was developed, the SME owner-managers and other staff who participated in the research (Chapter 5) were not particularly interested. In its prototype form it didn't help them in many of the ways they currently struggle with energy management such as billing, and it didn't help much in informing them of new ways they could improve energy management practices (Payne, 2000, Coles et al., 2016). The lack of utility of the prototype meant that I had to manage the expectations of the SMEs the tool was rolled out to. What helped was to not introduce the tool immediately (as this may have caused the SMEs to drop out), but to managed its role within the AR carefully, such that it was not relied on too much, meaning that if it were not very helpful, it would not compromise the participation of the businesses.

As has been found in the literature, it was also found within this project that there is indeed a large attention-deficit problem, and, whilst recent energy price rises may change this to some extent (Gausden, 2022), the cost savings potential of smart meter data on its own is not helpful enough to influence action in a meaningful way (Revell and Blackburn, 2007). This lends more weight to the need to be creative and find other ways to both research and design energy management interventions. By using AR methods described in this thesis has helped identify many opportunities to find ways in which this could be done, which are discussed in the next sections.

6.3.2 SME responses to the *development and testing* of smart meter data-based energy management tools

This section discusses how SMEs responded to the d*evelopment and testing* aspects of the research question, reflecting on both the AR approach, and actions taken to engage and explore the issue with SMEs and other actors. This is discussed from two perspectives, first how Hildebrand as an innovative business responded to the Competition brief, and secondly how owner-managed SME participants responded to the prototype and broader smart meter and other data exploration.

Considering Hildebrand's activities; entrepreneurship theory developed by Sarasvarthy et al (Sarasvathy, 2001a, Sarasvathy and Dew, 2005) describes entrepreneurs as innovating with means based on currently available resources, which can lead to a range of different effects depending on the path they end up taking (see Figure 13). In the context of Hildebrand's response to the Competition, this helps explain that they took the opportunity and resources provided by the Competition and applied this to their own context and resources (in the form of energy monitoring hardware; existing relationships with shopping centres, and the hospitality industry (via one of their partners)), and innovated using the combination of these. In developing the system, there was an implicit belief that the lack of attention issue was the main issue to overcome. It therefore made sense to the team to focus on other possibilities that the GlowPro system might provide to help increase its potential utility, thereby enabling improved energy management as a co-benefit of other uses for the system, which is discussed further below. Along the way, they made new connections and discovered new opportunities, which they have subsequently started to exploit. Looking at what occurred in this way, the development of outcomes which are different to what the Competition wanted should not necessarily be surprising. Policy implications from this are discussed further below (section 7.3.2).

Turning to the participating owner-managed SMEs, they were also shown to behave entrepreneurially in response to GlowPro and smart meter and other data. It was interesting that they used Effectuation to explore how they could use the data, but that because the main area of influence was in maintaining existing products and services, their over-arching goal in this context was to enable them to be more Causal (Anderson and Jack, 2000, Read and Sarasvathy, 2005, Berends et al., 2014b, Ciszewska-Mlinaric et al., 2016). Some implications from this are further discussed below.

RO 1: Informing the design and deployment of GlowPro energy management tools

In the context of developing energy management tools, this work helped to understand a number of issues relevant for working with owner-managed SMEs.

Firstly, as described above, within the context of entrepreneurialism theory, this identified owner-managed SMEs desire for gaining more control over elements of their businesses they have agency over. This manifests itself within the context of a) premises they occupy,

such as in the case of customer-facing businesses like the coffee-shops and cycle shops and b) processes, as in the case of the Roastery. From an energy management intervention perspective, this research helped make more clear that trying to influence energy demand, is actually attempting to meddle with core business activities, which are typically managed very closely (but from an operational, as opposed to energy perspective). This means that interventions are very likely to have unintended consequences for the businesses that would be hard for an energy management expert to understand without spending considerable time with the business to understand them. A similar finding was also shown in my previous research with high street retailers (Kenington et al., 2019), whereby resistance was found to suggested energy management interventions because they disrupted operational activities/processes, which were not necessarily obvious from an outsiders perspective. This helps us understand better why it is difficult to get take up, particularly in the context where the potential monetary benefits of interventions are limited. On the other hand, this also helps show that the desire for control can also be leveraged. For example, SMEs struggle for control and want more of it (Anderson and Jack, 2000), particularly within the context of developing and maintaining core business activities so if an intervention can give them more control (i.e. from an entrepreneurialism perspective, enable them to be more Causal) then they are more likely to engage. Furthermore, this is also a part of their business where productivity and performance are fundamental issues. In such a context, talking about 'productivity' is also important as this leads to things that SMEs are well known to be striving for, such as growth and improved profitability (Delmar and Wiklund, 2008). Historically, energy efficiency or demand reduction is often about either small cost savings, or operational details, which the more successful entrepreneurs are known to neglect or outsource as they distract from their fundamental goals (O'Regan et al., 2005).

Finally, SME owner-managers have usually become so by choice, which makes them want agency over what they do (Paul and Robert, 2000). This research has shown that this also relates to how they respond to interventions, giving them ways to have their own agency in how they are designed or deployed appears useful, given how they engaged proactively with my research, particularly when I shared the problem and opened up the discussion into actively seeking new opportunities (see section 5.3).

RO2: Improving understanding about how energy management can be improved

Further to the above, it is clear that the lack of attention issue is likely to be the most important substantive issue, amongst all of the range of barriers described in the literature (see section 2.5). This work has revealed new ways in which it can be overcome, and how it can also be framed to improve interest and influence. For example, just because SME owner-managers do not give time for energy management, does not mean they are not good at managing. Sophisticated systems are used for managing operations day-to-day and also managing financial and broader performance on a weekly/monthly basis. Simplistically, energy is not managed because it is a rarely visible underpinning service, and when information about it is provided, it is not provided in a way which bears relevance to their business activities (see section 5.2.5).

This thesis has identified a range of opportunities to integrate energy data within SMEs broader operational management systems. This will help them integrate energy concerns in with other operational systems, and also enable the translation of energy data into metrics which mean something for them (e.g. energy use per coffee served, energy use to produce Xkg of roasted coffee etc). These types of metrics would move the focus away from energy efficiency towards energy productivity. Energy productivity is a much researched field within major industry (IEA, 2014), however there has been little work in this arena in the context of SMEs. Whilst people and energy policy makers tend to focus more on energy efficiency, in the context of SMEs, energy productivity is arguably much more meaningful as a concept that includes a measure of how well a company is performing within its scope.

What is interesting about this is that there are technology providers out there doing this kind of thing already with other types of operational data (sales data, stock data, staff data etc.). They might not have been interested at the time of doing the fieldwork here, but they might be more so now with energy price rises (Gausden, 2022). This type of approach also lends itself to the entrepreneurialism notion of successful businesses outsourcing energy management to other actors (O'Regan et al., 2005, O'Regan et al., 2008).

Finally, as described above, even within the context of significant recent energy prices rises, it is unlikely that many SMEs are going to give a lot of attention to techno-economic 'win-win' cost savings-based arguments to act to improve energy efficiency (whether informed

by smart meter data and/or other means). This research identifies that SMEs desire control over premises and processes, revealing a number of different potential uses for smart meter data, which may, vicariously, lead to improved energy management (as a co-benefit). This is discussed further below.

RO3: Informing understanding about what other benefits (e.g. co-benefits) smart meter data-based energy management tools may deliver, or indeed whether it might be better to consider energy management as a co-benefit of other, higher priority actions.

The above lends itself well to thinking about energy management as a co-benefit of other more important things as a key way to conceptualise solutions to the energy management problem further. This supports, and provides additional possible solutions to add to previous studies that have identified that strategic non-energy benefits of improving energy efficiency exist (e.g. reduced production down-time, increased product quality or improved productivity (Killip et al., 2019). For example, it is likely to be more impactful to integrate energy (via smart meter and other data) within and around other operational data, both in making it more visible, and also in terms of enabling it to be viewed in more relevant ways, which can enable better management. Furthermore, as described above, using the data to enable them to identify how they can be more productive or effective in achieving their goals will be helpful (Pye and McKane, 2000). For example, alerts to warn whether a premises is likely to become uncomfortably hot during the day (using temperature sensors and weather data) can help them deploy mitigating activities like ventilation to happen earlier – which could help reduce the need for things like air conditioning. Furthermore, using smart meter data for other purposes, such as like premises activity management or as a quality control input.

Some of these opportunities like these may not seem to have the most direct impact on influencing energy demand reduction in of themselves. However, it probably isn't realistic to try and get SMEs to try actively to do this, given they tend to want to grow and are focused on sales instead of reducing what is usually a relatively minor operational cost. Also, if operationalised, opportunities like this will bring them much closer to their energy data than they have been before. Making it visible will make them more likely to improve their understanding of the energy-related impacts of their activities, which may help them identify opportunities to improve efficiency (or productivity). Whilst this has only scratched

the surface of the issue, this project has opened up new avenues to conceptualise how to engage with SME owner-managers more effectively. Ideas for future research to better inform this is discussed in section 7.4.

RO4: Contributing to understanding about applying an action research approach in this context, learning about its strengths and weaknesses and developing recommendations for future work.

AR and a participative, experiential epistemology: Benefits for energy management research of doing AR

Reflecting back on the rationale for choosing AR as the approach for this thesis; one of the main reasons for doing so was within the context of the increasing interest and need to understand the social and cultural processes by which behaviour-related energy demand arises (Roth et al., 2008). As described in the methodology (section 3.2.1), Roth et al. discuss that knowledge should be gained through engaging with the dynamic social and cultural processes which occur within real-life contexts. Using AR in practice, I believe, shows considerable advantages in helping do this, because there is not a layer of separation between the researcher and its participants. When considering the underpinning nature of energy demand, which is rarely directly considered by SME owner-managers (see section 5.2.4.3), it is clear from this research that attempting to change aspects of the energy system can lead to many unintended consequences. Within this context, from an ontological perspective, the participatory nature of AR comes into its own (Heron and Reason, 1997). It gives the ability to get much closer to participants and actively gives them agency to help inform helpful solutions, which given their business-related energy needs, seems very helpful.

Furthermore, the 'middle-ground' that the Participatory Research Paradigm (PRP) occupies between positivism and constructivism (section 3.2.2) is also helpful in supporting the elicitation of solutions to known social problems (Bhaskar, 2008). It really helps in giving necessary attention to the subject's perspective by giving them a participatory role in informing pragmatic solutions, which can work both for participants and for improving energy demand. Furthermore, the opportunity to do AR within the context of developing a new set of energy management tools helped both inform how those tools could be

developed in more helpful ways in future, but also helped identify and explore relevant theory, in the form of entrepreneurialism heuristics, which can help to inform other future energy demand-side solutions. This makes a good case for AR providing a promising future route for change within academia which is struggling with how to respond to the nature and scale of the Climate Emergency (Fazey et al., 2018, Umpleby, 2016, Aufenvenne et al., 2014). It would be worth considering if AR could be undertaken as a fairly rapid research activity to support and tailor new policies and programmes resulting from the current energy crisis.

That said, doing AR and trying to do it well is challenging, and some of the difficulties I faced are described below. Whilst the removal of separation between subject and object is one of the main benefits of doing AR as described above (Heron and Reason, 1997), it is also difficult to do well in practice. This became evident within social influences, where the backgrounds, norms and expectations of a group of different participants who come newly together to work on a common issue. From a personal perspective, the experience of working with Hildebrand in the early stages of the PhD was a bit like starting a new job, where you are not sure of the terrain and existing contexts and structures you need to get to understand quickly, whilst at the same time feeling pressure to add some value to the team in order to 'prove your worth'. In this context, there is much potential for misunderstandings and challenges to surface. An example of this occurred at the time I was developing interview guides for the energy consultants and security participants in the early stages of working with Hildebrand (see section 4.3). I had several discussions with Jane about this, who provided review and support during this time. Some of these interviews were done by telephone and recorded, so she also listened in and gave me feedback. Eager to support the team and do a good job, I had put quite a lot of effort into the interviews, but as we progressed I seemed to be getting quite a lot of challenge and questioning from Jane. I had been surprised by their relative lack of attention to energy management (see section 4.2.3), I decided that because these audiences (especially facilities managers and energy consultancies) would have a good understanding of energy management, I focused several question areas on understanding what they did in these areas. I did this on the basis that this could help inform whether and how a system like GlowPro could influence current practices. Jane asked me to remove almost all explicit references to energy management within the topic guides and told me not to ask questions directly about this during the

interviews. I did not understand this, and was slightly embarrassed when I found she had discussed the problem with others in the team, who then also came back to give me further direction. They decided that it would be best, rather than me using new topic guides which I had developed, that we should use some more generic topic guides, which had been developed at the start of part 1, with a little tailoring to cover explicit questions (e.g. for security managers). After some swallowing of pride, I went back to discuss further what they felt the issues were so we could find a way forward. I was conscious that time was short to complete the interviews and, whilst I felt it would be a shame not to explore some areas that I felt were useful, my priority was to not to waste the team's time and ensure I helped give what was needed before the end of the stage, which they could use to report back to BEIS.

Jane explained to me that there were good reasons for not exploring energy explicitly, nor talking too much about GlowPro and its current or potential capabilities in detail during the interviews. From a design perspective, they saw the value in fully putting themselves in the participant's shoes, which meant keeping GlowPro and energy management in the back of one's mind, whilst exploring their role and understanding very broadly how they managed day-to-day tasks. This meant for a conversation, which listens deeply to their issues and is unencumbered by our own concerns. She then described how this then feeds well into the (solutions focused) 'How Might We' (Figure 24) approach we took when interpreting the data – and that being the main mechanism by which we interpret our insights, which result in GlowPro developments.

I felt I could see the benefits of this, but I was concerned that we might miss the opportunity to explore specific areas of energy management, given some of the audiences, such as energy consultants and facilities managers, who managed energy as a core aspect of their roles. I asked whether, given several of our participants had close contact with energy data and managed it on a daily basis, wouldn't that therefore make sense to explicitly explore it? She said no. If they brought it up and wanted to discuss it, then that would be fine, but we should avoid heading down that road ourselves. She said the risk of being too targeted, was that you might well miss aspects of their work, which the system could help with and that exploring energy should wait until later on. Whilst I was not convinced of this approach, I

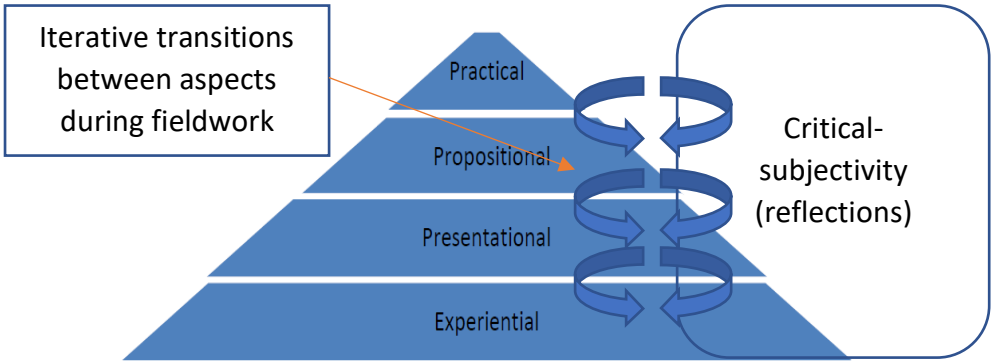
realised that I risked the opportunity of working together if I didn't acquiesce, so I did and subsequently did my best to stick to this plan during the interviews.

This example showed that whilst the experience can be difficult, it meant that we came away from the experience with a much better shared appreciation of each other's contexts. Using another work-based analogy, the outcome of it was like the feeling that one can get when you are working as part of a well-oiled team. Here, each team member has an implicit understanding of each other's relative strengths and weaknesses and you can pre-empt to a degree how others will respond to new situations and contexts, which can then be used to the teams wider advantage by enabling the team to leverage these strengths and supporting weaknesses, which is a trusting and often satisfying place to be. This is analogous to Kuhn's saying that; you can only truly understand a system when you try and change it' (Daston, 2020). The outputs of AR, whilst context-specific, feel like they have been 'stress-tested' so that participants in the process can feel confident in their findings.

From another perspective, it is possible to describe the development of knowledge formed as part of doing AR within the context of Heron and Reason's extended epistemology (section 3.5.4, also see Figure 46 below). At the beginning of this project; I experienced Hildebrand working in ways I did not understand, and which conflicted with my view of the world as an energy researcher. I had not explicitly recognised this at the time, but in practice what this meant was that I was not so much interested in 'innovation' or entrepreneurial processes, or even terribly aware of them. I was only really interested in understanding how to achieve positive energy management outcomes; which were grounded in my existing knowledge about energy demand reduction possibilities. As part of the AR process, once we had identified potential issues, we could describe our different perspectives (Presentational). This was uncomfortable at the time, as it involved me tactfully trying to explain that I was worried that they were not taking the goals of the NDSEMIC Competition seriously enough; and conversely Jane feeding back to me that they were having difficulty with my perspective because I focused too much on 'energy', which they felt wasn't helpful at this stage of development of the system. Furthermore, the team also weren't very clear on where I would be able to help within the team as I had little experience or interest in new system design. Working through these issues led to a much better working relationship (Experiential), whereby we identified different work-related

tasks we could work together on (e.g. I could support more on research with middle-actors we had identified as I had better knowledge of them (see section 4.3). This also led to the identification of, and new discussions about, entrepreneurialism, which helped identify Hauser et al. (2020)'s theoretical framework within which I would explore much of the rest of the PhD (Propositional). Finally, the culmination of this process led to the development of practical knowledge which is discussed in the context section of this discussion chapter, described above (Practical).

Figure 46 The four aspects of an extended epistemology (Heron and Reason, 1997)



Reflecting on Heron and Reason's extended epistemology, this shows that the four aspects they describe are relatable. However, they do not operate linearly or sequentially in practice. In practice, you tend to iterate between the aspects, with much 'toing and froing' as you make progress through the project; and it isn't really clear where you will end up at the end of the research (which is another well-described feature of AR (Bradbury and Reason, 2008)). Finally, as is also described above, it is the reflections and 'thinking' (which took up a lot of time and effort) that really helped make progress and improve understanding throughout. And this is why the personal and team reflections play a prominent role in the findings (see reflections sub-sections throughout Chapters 4 and 5).

The experience of doing AR in this way, helped reveal to me that it is something of a nonsense to try and consider that any researcher plays a separate, dispassionate role from their research participants, which is often implied implicitly or explicitly within much academic research. Whether doing AR or other forms of research, in practice it makes more sense to actively consider the influence of the researchers and participants together and explicitly consider how they may influence findings and conclusions drawn (Reason and Torbert, 2001).

Naturally, many alternative research designs could have been employed within the context of this study; for example, a qualitative case study approach would have likely also been illuminating. However, it is difficult to conceive of alternative approaches which could help identify the depth of issues described here, within the scope and context of a PhD study.

The experiential aspect of working with Hildebrand brought several benefits. Firstly, it led me to better understand how projects like this get designed and how they do it. This project revealed how complex and multi-faceted the design process can be, which has implications, particularly for future policy interventions and related energy demand research (see section 7.2). Whilst academia so far has focused on grappling with understanding what the barriers are to energy efficiency take up and theorising about that; Hildebrand intuitively 'knew' that attention deficit was ***the*** major issue and sought to innovate around that to overcome it. It also shows, through the entrepreneurial process, that the desired outcomes of an intervention can change quite quickly. This is discussed further later, but it suggests that when developing new innovations within policy, it would help to recognise and embrace some flexibility around outcomes as this will help support entrepreneurial processes to flourish. That said, policy evaluation projects should also focus on understanding what outcomes were achieved (intended and unintended) to help better understand how they relate to desired outcomes and why to inform future policy designs.

Secondly, it also helped reveal during the second part of the research, again through the experience of being with the SMEs and sharing the design issue with them, that the lack of attention issue was going to be better served by integrating smart meter data into other operational systems, not by developing a proprietary separate system (as was implicitly advocated by the NDSEMIC Competition). One aspect of this is likely simple energy management 'nudge' based information and advice as it appears where they are already looking (Thaler and Sunstein, 2009). This type of intervention would be cost-effective, and likely to be more welcome now given recent energy price rises, which are affecting SMEs (Gausden, 2022). However, more fundamentally, doing this would enable (or even force) the data to be used in ways to produce outputs which are more relevant for SME activities (Chartered Institution of Building Services Engineers, 2013) and thereby also more aligned with energy productivity issues (as opposed to energy efficiency) as described above. Such analyses would be difficult to do within a proprietary energy management system, as it

would need development to ensure relevant operational data was synthesised to help the business, which is likely to be different for different sectors and costly to do. However, doing it the other way around is much easier – as you are introducing smart meter data into systems already designed for those businesses, which is a more straightforward and pragmatic prospect.

Finally, and perhaps most importantly, it is hard to conceive of being able to have made the explicit links between entrepreneurialism and energy management research, had I not had the experience of working so closely with Hildebrand. Whilst linking theory about SME entrepreneurial decision-making and energy management seems like a good idea on the face of it, it was only really during the process of being with and contributing to the GlowPro project that the fundamental drivers of entrepreneurialism and how they influence projects like this became very clear.

Contribution to AR methods from doing it within SME energy management

I described in section 3.5.8 (defining a role for AR in SME energy management studies), that doing AR in the SME energy management field would be interesting because it is an issue where one of the principle problems is lack of attention and AR is usually undertaken when participants come together to work on an explicit issue of shared concern (Bradbury, 2015). Reflecting on this experience, there are two areas of interest which came through the work.

Firstly, in the context of working with Hildebrand, there was an explicit, shared concern that brought us all together, which was to develop the GlowPro prototype. This shared concern had different drivers for the participants; for Hildebrand this related to using the funding opportunity to develop something which would commercially successful, whilst there was also a shared aspect across the teams which was to use the opportunity to improve energy demand. Within the project, the effect of this was to evolve the desired energy management outcomes to create a product that was more attractive and likely to be used by the target audience. As discussed further below, whilst this challenged the ultimate desired outcomes of the Competition, it did also help make progress by helping identify other ways in which energy management could be brought to the target audience's attention.

Secondly, when working with the SMEs, it became apparent that, whilst energy management was not a high priority concern, it wasn't ***not*** a concern. Interestingly, the concern appeared to be more strategic, in terms of being a responsible low carbon business, as opposed to investigating potential cost savings (which helps to highlight further that the cost-savings driver for improved energy management is, primarily, a red-herring). This meant that it was reasonably straightforward to engage them in the project on this basis. What was more challenging was being able to have 'honest' conversations about the existing energy management context within their businesses. For example, there appeared to be hurdles to get over because sometimes, participants were slightly embarrassed about how little attention explicit energy management activities were given during the day-to-day management of their businesses. Getting to this point required getting to know the participants, their businesses and the contexts they worked in well enough to enable such conversations. Even at this point, the introduction of GlowPro in its prototype form was quite far away from what would be useful for them, it was difficult to engage them in further discussions. Only after this, when 'sharing the problem' with them (section 5.3), the most valuable discussions about how smart meter and other data could be effectively integrated into the conversations and new, informative insights which felt genuinely helpful appeared.

The experience of this work suggests that this kind of up-front contextual, relational work should be given deep consideration, in future AR (or even non-AR) energy management research. It lends further weight to some of the methodological criticisms of previous energy management research (Hampton and Fawcett, 2017) and potential for mis-interpretation of the findings of other work which has not done this.

7 Reflections and Conclusions

This final chapter provides over-arching reflections and conclusions emanating from the PhD. It begins by considering issues of validity, quality and study limitations, followed by a description of the contribution of the thesis and implications for policy, industry and academia. This is followed by suggestions for future research and finally a summary of conclusions.

7.1 Validity, quality and limitations

As described in section 3.2.6 of the method, the PRP, in developing knowledge which is closely related to and built upon actual practice, is cautious in how its findings can be interpreted and therefore does not purport to develop single valid 'truths', but develops theory about how best to act in a particular situation (Reason, 2006). This means that this thesis can be interpreted as having degrees, or levels of specificity or validity according to the three different perspectives described by Reason and Torbert; self (first-person), co-researchers (second-person) and wider communities (third person) of shared interests (Reason and Torbert, 2001).

First, from my perspective as a researcher and considering my own practice (first person), this project has helped me grow as a researcher, and see the benefits and difficulties of doing AR well and the broad range of skills this requires, but also the benefits of doing it. I am convinced of the value of doing research in this way.

Secondly; considering my co-researchers (second person) this has led to a much better understanding of the stake of, in particular, Hildebrand and how their priorities work within the context of a Competition such as this one. It also has revealed how much can be learned from working with SMEs in a participative manner to inform energy management interventions. Whilst energy management researchers bring useful experience to the table, this project has revealed the many useful things which can be learned from SMEs, and that it would be impossible to design helpful interventions without bringing them actively into the process.

Thirdly (third person), this thesis is the culmination of contributing to the wider community of researchers and practitioners investigating the improvement of energy management. In this context, I have been cautious in terms of not taking forward the Hauser framework and further developing it specifically for the purposes of better informing energy management

interventions. Inductive analysis of findings within the early stages of the project served to identify the three entrepreneurialism heuristics (Causation, Effectuation and Absence of Strategy), as a useful framework which can be used to inform the characterisation of SMEs, and specifically how they may respond to different outside influences. I have used this project to identify and use the theory to show how it could be useful for future research. The context of this study being specific, it feels that this would be over-stretching the quality and validity principles set out by Reason and Torbert to attempt this within this study. In section 7.4, suggestions for future research are made which could further explore the links between the energy management and business management disciplines to further develop this area of theory to better inform energy management interventions are described.

Finally, considering the limitations of this study further; some further words on the influence of critical subjectivity are necessary. Whilst critical subjectivity is a crucial feature of AR; operating on principles of democratic participation, cooperation and empowerment by providing participants with considerable agency through the projects. Without this component, there a clear risk that the methods used can reinforce one's own assumptions as described by May (May, 1999).

"*it is possible that researchers will omit a whole range of data in order to confirm their own pre-established beliefs, leaving the method open to charges of bias*" (May, 1999, p 154).

Within this project, this was mitigated for by openly discussing (both with Hildebrand and participant SMEs) the interpretation I was drawing from the study, and I actively sought further input from them on key issues.

I mitigated for this by ensuring that both Hildebrand and the SMEs were aware of the interpretations and conclusions I was drawing and I actively sought out challenge from them. There are various examples described within the chapters above, which lead me to conclude that this wasn't the case. For example, the fact that one of the participating SME owner-managers wanted to explore the potential commercial opportunities from our discussions gave me confidence that my interpretations had validity.

7.1.1 Lessons learned

Undertaking this PhD thesis was a considerable learning experience, particularly because of the choice to use an AR approach, which I had had very little experience of beforehand. Below, I reflect on the main lessons I took away from the project.

1. **Resource requirements for undertaking AR**: AR is time and resources intensive to do well in practice and it required considerable investment of time and also broadening my skills. The most challenging but rewarding aspects involved managing the evolving relationships with my participants, given their active roles in the project and my need to continue to secure their commitment through the project. My approach to this was informed by previous case-study research I had undertaken with high-street retailers (Kenington et al., 2019). What was different about doing this research, was that it appeared that by giving my participants explicit agency in the project (as is the case when using AR methods), the SME owner-managers (chapter 5), who had no self-evident reason to participate, engendered a higher level of commitment than I had anticipated. I spent considerable time developing my approach to minimise time and resources commitments needed from them, for example by always going to them at their place of work, and sensitively working around their existing activities. I found that, particularly after the first few visits, they were keen to be involved and seemed to enjoy the experience. They got in touch with me proactively when they had thought of new ideas, which on reflection means I probably could have asked for more from them. For example, I had ideas to conduct a shared workshop where I got them all together to discuss issues, which would have been valuable in retrospect[90].

2. **Critical subjectivity**: As described above, this part of the project was completely new and involved a steep learning curve. At the start, I don't think I was aware enough of what preconceptions I brought to the research. For example, I brought knowledge about energy management and an explicit interest in energy, which ended up being a bit of a problem. In any future AR projects I get involved in, I would try to be more sensitive, and self-aware of what contexts I bring. Especially as

[90] Sadly this activity was curtailed by the onset of the COVID pandemic.

within AR you are an active participant, this has influence not only within how you interpret your findings, but also in how you conduct yourself within the project. I think that it was because of this interaction with participants, that I became more aware of this and it helped me think differently about critical subjectivity; both in the role it plays and how to do it. Having experienced doing this in practice however, I now think differently about risks of researcher interpretation bias, which is likely to manifest itself within other, more traditional research methodologies (e.g. qualitative case-study research). These methods do not get the benefit of having participants working with you, who therefore cannot discuss and challenge directly the interpretations you make.

3. **Developing and utilising 'informal' AR fieldwork approaches**: As described in the methodology (section 3.5); the research undertaken within this PhD in practice was characterised by decidedly informal ways of working, both within the Hildebrand project team and also the owner-managed SMEs. AR methods guidance features participants undertaking formal activities, such as participative and facilitated workshops or group discussions, but many of these were not going to be appropriate in this context. For example, whilst working with Hildebrand, we had collaborative meetings and discussions, but they were not formally facilitated by anyone, but were more organic, and those who wanted to speak did, depending on the nature of the conversation. This meant that the best way to approach the fieldwork was to be prepared to discuss a number of topics, which I had identified as current issues before meetings took place, and then raised these opportunistically during the meetings as and when it was possible to do so. Whilst this felt quite messy to do, it worked in the end quite well, and also had the advantage of being quite suited to exploring new tangents and issues of interest, as the discussions were not constrained to formally decided upon agendas beforehand. That said, given the opportunity again, I would try to exert more agency over the discussions, particularly in the earlier stages of the project, which likely would have informed my findings better and more quickly.

7.2 Action Research in energy demand studies and ethical considerations

This section discusses ethical considerations of undertaking AR within the context of this study. Ethics in action research, as described in section 3.7.3, when working with organisations in this way takes on set of broader considerations than for more traditional forms of social research. To support this, the AR community has developed guidance for developing ethical frameworks, for example those developed by McKay and Marshall (2001) and Davison et al. (2022).

Below, specific ethics related issues which arose are discussed that may help future researchers consider ethical issues when employing AR methods in future.

Figure 47 provides a summary from the Sage AR handbook that describes the tasks and skills required to do AR with (i.e. within) organisations, considering first, second and third person AR perspectives (see section 3.2.6 for definitions of these perspectives and how they are used within AR)[91]. The figure provides a helpful overview of the types of tasks which are required and skills needed by action researchers to enact them effectively across three interlocking challenges; preunderstanding, role duality and organisational politics, Coghlan and Brannick (2014). Below I describe issues pertinent to each of these areas that were relevant during this research[92].

[91] In the context of this discussion about AR ethics, this will relate specifically to how the researcher thinks and acts to be positively helpful (and not risking causing harm) in the context of their AR research considering their own self-awareness (first person), how they interact with co-researchers within their AR 'team', as well as others they may come into contact with (second person) and how they communicate their findings with wider communities (third person).

[92] Note, each of the different person perspectives are not covered comprehensively. Person perspectives are only described where there were specific issues and challenges which were noteworthy within the context of this project.

Figure 47: Preunderstanding, role duality and organisational politics in first, second and third person practice (Bradbury, 2015)[93]

	Preunderstanding	*Role Duality*	*Organizational Politics*
1st Person	Task: Developing spirit of inquiry in familiar situations where things are taken for granted Skills: Attending; Questioning own assumptions; Self-awareness/ reflection skills	Task: Holding and valuing both sets of roles simultaneously Skills: Catching internal response to conflicting demands and dealing with them	Task: Learning to act politically in mode within values of action research Skills: Acting politically and authentically
2nd Person	Task: Developing collaborative inquiry/action in familiar situations where the spirit of inquiry can be diminished Skills: Conducting critical and collaborative inquiry and action	Task: Holding and managing the demands of both roles, particularly in situations of conflicting role demands Skills: Role negotiation with significant others, esp. superiors	Task: Surviving and thriving political dynamics Skills: Being a political entrepreneur
3rd Person	Task: Developing practical knowledge of how to inquire as a 'native' Skills: Linking practice with theory	Task: Develop practical knowledge of how the dual roles impact on action research and contributing to insider action research role identity theory Skills: Linking experience of role duality with theory	Task: Articulating knowledge out of action that is actionable politically; Contributing knowledge of what organizations are really like Skills: Linking political experience with theory

Preunderstanding is the concept that action researchers need to build on the closeness they have with the setting they are working in whilst also creating some distance from it in order to see things critically and enable change to happen. When working with Hildebrand, as described in Chapter 4 (4.2), I had to re-evaluate my own preconceptions about what I took for granted (first person) about researching energy demand related issues with organisations, in the context of trying to help design GlowPro, which appeared to be more effective when talking very little about energy explicitly, and fully putting myself in the shoes of our research participants to fully understand their problems from their perspective and only bringing in energy demand issues afterwards when conceptualising how GlowPro could be used to help solve issues. This was a challenge for me personally because I had several years' experience of doing energy demand related research and meant I had to 'unlearn' certain aspects of that. This might be less problematic for a researcher with less direct energy demand related experience, as they may be more open to new and different ways of thinking than I perhaps was at the time. Conversely, when working with the owner-

[93] Note that this table focuses on issues from the perspective of the action researcher actually working within the organisation setting of study. In this study, this was not the case as I came in to work with them from an external organisation. However, the closeness of the relationship developed means that many of these issues applied, so it felt appropriate to use this framework here.

managers (Chapter 5), it took some time and effort to build relationships with my participants to get to a context of trust and openness (2nd person) to enable them to feel like genuine collaborators working with me and, for example, them not feeling concerned or embarrassed about their relative lack of knowledge or attention given to energy issues.

Role duality relates to taking advantage of the 'insider' position an AR researcher occupies to both support useful research outcomes, at the same time as supporting and helping support successful outcomes important to the organisation(s) in question. When coming from outside to work within a team but not being paid for it, such as when I worked with Hildebrand, there is a risk of the researcher being seen as a free resource, and being exploited, which could undermine the achievement of my own research goals. This is an ethical consideration where the risk manifests itself on the researcher, not the participant and is more of an issue within AR projects than in other forms of research (Holian and Coghlan, 2013). In the context of this project, I was aware of this risk and so sought to manage it from out outset, particularly as the team appeared to be working at a fast pace (to meet NDSEMIC Competition delivery timescales) and suffered from lack of resource capacity at times. It was clear from the discussions I had with the Hildebrand team at the start of the relationship that they viewed that I had some value for them, partly because of my experience of working within BEIS on the design of the Competition. I therefore leveraged this in an open and transparent way, which enabled us to have concerted discussions about what benefits I could bring them through the project, and how they could in return help me achieve my own PhD related goals. Much of this was agreed informally and verbally, which suited the team's informal style, and also the fluidity of the situation at the time. Alternative approaches could have included writing and agreeing a 'memorandum of understanding', or even signing some kind of contract.

Whilst working with Hildebrand, I did spend time actively considering whether and if so how I might be exploited when working with the team, and it did not materialise into a significant issue. This may have been helped by the attention I gave it, but also the wider context of my being a more mature student, who was perhaps viewed more as an equal than other PhD students in the same situation might. I discussed the issue and sought guidance from my supervisors, who were very helpful in supporting me in developing the relationship, and it would be an area where less experienced students could leverage

further support to mitigate this risk. Specifically considering ethics, some considerable time was spent on developing the research the ethics submission agreement, which was signed with Hildebrand (section 3.7.3), with support from the UCL BSEER ethics team (Gelling and Munn-Giddings, 2011). This clearly set out boundaries in terms of how information would be used and what to do if either party had issues, including routes for third party communication (e.g. with supervisors) should the relationship develop problems. I also signed a Non-disclosure agreement with Hildebrand prior to them sharing commercially confidential information with me.

Organisational politics follows on from role duality and relates to balancing the needs of the action researcher with the needs of the organisation within the broader context both are operating within. This was perhaps the most challenging area of the project, manifesting across all three person perspectives and had broader implications than just ethical considerations within the project. Undertaking the research required several aspects of organisational politics to be considered. For example, there was internal organisational politics involved working within the Hildebrand core team (e.g. maintaining relationships between team members); how Hildebrand interacted with other organisations they had partnered with in bidding for the Competition; how they interacted with BEIS as the Competition funder and how they interacted with other Competition projects, as well as the broader smart meter and IoT market. Within this kind of operational ecosystem there are many vested interests at play, some of which are obvious and others less so and they all had to be navigated in order to ensure the project could continue and also have successful outcomes. Some examples of this are described below. It is one thing to need the skills to navigate organisational politics when ensconced within the activities and needs of an organisation you are working for. Adding in the role duality elements described above made it more complex and multi-faceted, which was both interesting and difficult to navigate successfully. For example, Chapter 5 describes a number of ways in which the goals of BEIS through the Competition and those of Hildebrand deviated, principally as BEIS were interested in achieving energy demand reduction goals through the tools directly, whereas Hildebrand wished to develop a tool, which was useful and would be used by the target audience, leaving the targeting of energy demand improvements as a secondary outcome of the project, tackled later on. I could understand both perspectives, but also saw that there was a risk that Hildebrand may not continue to be supported through the

Competition if they did not give energy demand reduction goals greater priority, or at least make concerted attempts to clearly explain the rationale for their approach and why it may end up being more successful in the longer term. I spent time and effort trying to help them temper how they communicated with BEIS to support this, whilst not compromising the approach they were taking. This was only partially successful, and I found that at times, the team accused me of not understanding their approach and taking 'BEIS's' side, which I felt sometimes compromised our working relationship somewhat. This was tricky as I risked being unsuccessful both in helping them secure continuing funding support, *and* compromising my ability to do my PhD research with the team. It took diplomacy and tact to ensure I did understand and appreciate their position, and that what I wanted to help them do was in effect support their communications from a public relations perspective, rather than try and change it fundamentally. Surviving and thriving through this kind of politically dynamic situation took effort and skill, and it was difficult to clearly see the influence of these efforts on the outcomes of the work, which was frustrating at times. This is an area, which may not appear challenging at the start of a project, however it could be difficult for early-career researchers to navigate, particularly if they have had limited exposure to different kinds of organisational politics.

Finally, within the domain of the third person there lay challenges in articulating knowledge that is actionable politically, and balancing this with my own needs as a PhD researcher providing an accurate account of what happened, for example through this Thesis. Hildebrand have been given the opportunity to review the entire thesis, and they have reviewed large parts of it. I am confident that the thesis provides an accurate summary of what occurred, which fully supports the study conclusions. However, there are some elements and details that, whilst they do not materially change the conclusions, they would not be appropriate to include here as a formal written thesis. This is because they potentially engender some reputational or other risk to one or more of the parties with whom they worked. An example of this is that, whilst all three of the owner-managed SMEs stated they would be happy to be described in an attributable format, I decided to anonymise them. One of the reasons for this was because they imparted some activities, which were dubiously moral or actually illegal. An example of this was the cycle-shop not having paid electricity bills at one of the monitored sites. They described that they had made concerted, evidencable attempts to pay their bills so they were not concerned about

this. However, directly attributing them in this research came with a risk of causing them issues as a result of doing this research and the thesis. This is where the recommendations of McKay and Marshall (2001) and Davison et al. (2022) to develop an ethics framework, which is broader than that of traditional research projects makes good sense. It should specifically describe issues pertinent to the research, and which can be used as a way of navigating through problems during the research should they arise.

7.3 Contribution of this thesis

7.3.1 Academic contribution

Using Hauser et al. (2020)'s framework here is the first time that the SME energy management and SME business management literature disciplines have been brought together. This framework, being based on decision-making helps takes steps towards overcoming one of the major challenges of SME energy management research, which is its heterogeneity. It does this by focusing not on SME goals, or activities but on how they make decisions. Many SMEs are family or owner-managed (Pahnke et al., 2022), and so looking at the problem from this perspective enables the consideration of a large proportion of the overall SME sector. It has its own limitations, for example, it doesn't overcome very specific, sector-based activities, which are likely to further benefit from the 'small science' approached advocated by Chester et al (Chester et al., 2020), but it does help consider the issue in a more generalisable way, and at a level of abstraction, which is helpful for policy and academia.

Going back to the broader literature describing SMEs in the context of energy management, there are several ways in which the entrepreneurialism decision making framework supports or challenges current discourses that seek to promote improved energy management in SMEs.

Firstly, the entrepreneurialism framework challenges the techno-economic 'win-win' approach, which has been the primary focus of some previous SME-targeted interventions. As other research has also found, the cost savings aspects of improved energy management is not attractive enough on it's own (Revell and Blackburn, 2007) and in fact, the entrepreneurialism literature suggests that only less well performing businesses ('laggards' as described by O'Regan et al) are likely to be attracted by this focus (O'Regan et al., 2008).

This study suggests that if the focus is changed to focus on enabling businesses to have better understanding and control of their premises and processes, this is likely to be more effective as it leverages the desire for increased Causation, which is a clear finding from this research.

The Hauser framework can also augment other approaches described in the literature. For example, taking a values-based approach (Hampton et al., 2019) helps to leverage broader organizational goals often seen in SMEs (Douglas and Shepherd, 2000). Using the Hauser framework in this context can further help to understand how different SMEs will consider and respond to an intervention and why this may happen. Understanding that SMEs will consider an intervention using Effectual decision making, helps understand how they may come to either taking up or rejecting an intervention, and help understand reasons for it.

Finally, looking at the three lenses of organisation characterisation described by Decanio et al (DeCanio, 1993), and the 4Cs framework developed by Janda et al (Janda, 2014a), the entrepreneurialism framework focuses mainly on the 'organisation' lens, which has limitations given energy management is influenced by a range of actors (e.g. middle-actors) (Janda and Parag, 2013, Parag and Janda, 2014). There are two aspects, where Hauser can be helpful in this context. Firstly, within an owner-managed SME context, the 'organisation' has considerable influence within the whole system. Secondly, the Hauser framework can help to understand how an organisation may respond to interventions and thereby help inform how other actors can adapt, based on the types of responses which the organisation may observe.

7.3.2 Policy and industry contribution

Identifying new ways to improve SME energy management: This thesis has identified new ways of making energy management information, derived from smart meter and other data more relevant for SMEs.

SMEs do not think about energy as an explicit concept very much, outside of billing and other tactical activities. As such, when explored using Hauser Hauser et al. (2020)'s framework, in the context of other operational activities (e.g. operations management, staff management etc) it is revealed as an area where SMEs exhibit Absence of Strategy in their decision-making. Reflecting on the energy management literature, this is not necessarily

surprising because energy use in relation to business activities is not easily visible or measurable. Smart meter and other data have the potential to help make these connections (Fischer, 2008), which can help reduce Absence of Strategy in this area, which is what the SMEs who participated in this research wanted (section 5.3.4).

In the context of the NDSEMIC Competition and developing effective energy management interventions, this thesis has helped reveal future ways of integrating such data in ways which are more likely to be more effective in helping to improve energy management. Firstly, to help overcome the attention-deficit problem associated with energy management, this project helped identify that more helpful energy management tools are required. Rather than developing new proprietary tools, such as was done through NDSEMIC, it is likely to be more effective to integrate smart meter and other data to include energy management functionality within existing dedicated SME operational tools. Many consumer facing SMEs use sophisticated point of sale (POS) systems, which are used to managed sales, and are increasingly integrated into other supporting systems, such as stock and staff management, and importantly they are also used actively by owner-managers and premises managers to measure and manage the day to day activities and profits of their sites. Furthermore, aggregated smart meter data can also be integrated into SME accountancy systems (e.g. Sage, QuickBooks) systems. Owner-managers and business accountants use these systems to pull in sales and costs data on a monthly or more basis to inform monthly managed accounts. Integrating energy management information into these systems makes sense to include energy management within the scope of these systems, but it also would likely make sense as it would likely be a natural extension of current uses of the system, which is used to take strategic account of overall business costs. Such activities would not only enable energy management to be brought within scope of these existing SME management activities, but in their integration, the data would be much more likely to be able to be made relatable to activities. This would help improve understanding of how energy demand correlates with activities, which is likely to initiate better management. Therefore, if future innovation competitions are undertaken in this area, it would make sense to target these management systems providers as a vehicle for innovation, perhaps suggesting that they partner with smart meter data experts, like Hildebrand and others who participated in NDSEMIC.

Finally, looking at it from a broader perspective, given what occurred within this NDSEMIC Competition project (where the development of an explicit tool or set of energy management tools was encouraged), an alternative approach future approach could be to task innovators with simply improving energy management, and being much less explicit in how they go about doing this. This approach may be more helpful to ensure that participants do not stray from policy goals by enabling them to be more creative and flexibly in the means by which they seek to achieve the outcomes.

Overcoming the attention deficit issue: During part 1, it was interesting that Hildebrand identified this as the key issue to overcome within the development of GlowPro from the start. As described in the literature review (section 2.5) there are many barriers to energy management in SMEs, but Hildebrand decided from the outset that this was the main issue to focus on. This is a useful finding in of itself, as it helps inform the relative priority of this barrier. It makes intuitive sense because if businesses are not engaging with energy management at all, then all the other barriers become irrelevant. Focusing on this challenge, as entrepreneurs led Hildebrand to handle this challenge Effectually (Sarasvathy, 2001a) which got them into the territory of combining energy data with other operational issues, to develop a tool which would cover both aspects and therefore be more useful. This led to the security and cleaning aspects of the issue. This led to challenges with BEIS as these were less well aligned with the desired outcomes of the competition. This view is understandable, but the approach Hildebrand took made further progress in an area, which has struggled to make progress in recently. They achieved this by being flexible with goals and trying to align them with that of the businesses they engaged, which from an efficacy perspective is likely to be a good idea. This suggests that, particularly for innovation competitions, they could either take more risks in this area, accepting that some flexibility in outcomes is needed otherwise you risk ending up with something which isn't very innovative, and less likely to be successful. Or, as described above such competitions could be more successful if they focus simply on desired outcomes and allow flexibility for innovators in how outcomes are achieved.

More broadly, these findings suggest that integrating energy management into broader operational activities, and approaching it a co-benefit of other more pressing activities is likely to be a more successful strategy.

Making energy management information relevant: SMEs within this project identified how current smart meter data outputs do not provide information in a manner which is relevant to them and their activities, nor is it relatable. SMEs monitor key performance metrics, such as sales, turnover and profits; and these are usually related back to their costs of what they produce. In the case of the cafés chain, number of cups of coffee sold per day/week/month was the main 'currency' of relevance to the business, and all costs were analysed in relation to these activities. Providing energy data that relates explicitly to this kind of metric would make it much more enabling for SMEs to measure and manage energy usefully. Such metrics would enable analysis of how energy use varies according to activities, and start the process of identifying potential improvements, either through reducing wastage (e.g. turning off equipment whilst not being used), but it could also be used to help understand the impacts of efforts, and help identify worthwhile energy management activities.

More broadly, the thesis helps identify better ways to communicate energy management information, which aligns with business goals. Energy efficiency and cost savings are not particularly interesting to SMEs (section 2.5); however, as shown by the Hauser framework, what SMEs do want is to be able to 'control' their businesses more tightly and enable them to be more productive than previously. Utilising these concepts of 'greater control' and 'productivity' would be more helpful ways to discuss energy management information for this audience and likely to engender greater interest and take up of interventions if they are described in these ways.

This comes with some challenges for how energy demand management is conceptualised within energy management literature. For example it more clearly shows that reducing demand and perhaps to a lesser degree energy efficiency is conceptually problematic for SMEs, as they conflict with how successful businesses and growth are achieved. An energy productivity focus would help side-step this issue. More work need to be done in this arena to fully understand this, however there are some benefits to considering the development of interventions in this way in future. For example, this identifies avenues whereby energy management SME policy can align more closely with business support and economic growth policies. Something clearly relevant in the UK as policy for energy and business occupy the same department (BEIS).

7.4 Future research

Within the context of the under-researched SME sector and energy management issues, there are still many gaps in the literature, and a plethora of future research projects would be worthwhile. Considering this study within the context of better understanding SMEs behaviour in relation to energy management, and within that the potential for smart meter data-based interventions, the following suggestions are made.

Firstly, it would be beneficial to design future studies which embrace the entrepreneurialism heuristics identified and explored within this study further to better inform how they can help inform the characterisation of SMEs in regards to energy management and how they interrelate with other previously developed approaches. For example, a study explicitly designed to empirically test these heuristics within the context of SME energy demand-related behaviour would be useful. This would improve confidence in the findings and explore how theory could be further developed specifically in the context of responses to outside influences, such as energy management interventions. Another approach which would also be useful is to explore how the entrepreneurialism lens supports and/or challenges other existing frameworks which have been development within energy management research. For example, above some tentative suggestions are made about how Causation, Effectuation and Absence of strategy heuristics can support the 4Cs framework, developed by Janda et al (Janda, 2014b). It is likely that entrepreneurialism frameworks can augment the 4Cs, by providing a better way of understanding how organisations evaluate the 'Concerns' and 'Capacity' elements of that framework. Furthermore, one of the really interesting challenges of energy management within the context of larger organisations, is the complex ecosystems they occupy and the challenges this engenders, such as that previously described by Janda et al in the context of development of the middle-out perspective (MOP). It would be interesting to explore whether and how entrepreneurialism frameworks influence the different actors involved within the MOP, and whether and how it can help inform responses by the different constituents of the ecosystem MOP considers, especially given the agency middle-actors are seen to have on influencing energy demand.

It would also be interesting for future work to investigate relationships between the values-based lens, which has been further developed recently by Hampton et al (Fawcett and

Hampton, 2020, Hampton et al., 2019) and entrepreneurialism. Pro-environmental values clearly influenced the SMEs involved in this research, but I did not explicitly explore how this influenced their decision-making. As discussed earlier, the main difference between these two lenses is that values focus on goals and aspirations (see section 2.7.4), and entrepreneurialism heuristics explored here focus on how decisions are made; so it would be interesting to explore how these two frameworks interrelate.

Finally, from a methods perspective, I think this AR study helps make the case for conducting future AR studies, not only within SMEs, but the broader demand-side energy research discipline. As described in several places within this thesis, AR provides a very useful potential method to conduct targeted and impactful academic research, which can respond more helpfully to the context of the broader Climate Emergency (Fazey et al., 2018, Umpleby, 2016).

7.5 Final Conclusions

Below a brief summary of the overall conclusions from this thesis is provided in response to the research question.

How do owner-managed SMEs respond to the development and testing of new smart meter data-based energy management tools?

At the contextual level of inquiry, conclusions from this study include:

Owner-managed SMEs respond to smart meter data-based interventions in an entrepreneurial manner. They consider what benefits it may have for their business and consider what opportunities it might confer to them, using Effectual decision-making frameworks. This appears to occur within the broader context of SMEs wishing to enable themselves to make more Causal decision-making within aspects of their businesses over which they have considerable control. Using entrepreneurial frameworks as a lens by which to consider the design and development of smart meter data-based interventions will likely help improve their design and delivery.

Using entrepreneurialism as a framework here, suggests that:

1. Smart meter and other data-based interventions can improve SME abilities to control their premises and processes. Within this context, there are a range of

potential uses for smart meter and other data, which can help improve operational management in areas including productivity, quality, staff management, health and safety, marketing and management of internal environments.

2. Improved energy management is likely to be a co-benefit of utilising smart meter and other data to support these other identified benefits. Whilst it is uncertain what the effect of utilising smart meter data is, it is likely to lead to more productive energy use and better energy efficiency.

At the meta-level of inquiry, conclusions from this study include:

3. Action Research is a useful and appropriate approach to use in energy management studies. They can be helpful to inform how target audiences respond to interventions and, in this context is, able to provide insights that other approaches would struggle to.

Appendices

1 Appendix: Thesis background and early research

This section supports the background and context to this thesis by describing the background to my personal interest in the ND sector, as well as research and exploration I undertook in the early stages of the PhD. The section provides additional context and explains some of my personal interests in better understanding small business energy demand and how it can be influenced, which augments section 3.3 of the Methodology chapter. The descriptions below do not directly contribute to the findings (and hence it has been appended), however it has been included here as it was instrumental in the development of the approach and how I came to focus on undertaking AR with owner-managed SMEs.

I had developed an interest in the ND sector, which arose out of undertaking some consultancy assignments looking at ND energy demand prior to undertaking the PhD. These projects included working for BEIS to evaluate the Carbon Reduction Commitment (CRC) policy (CAG Consultants, 2014), which targeted large organisations, and also evaluating the Energy Saving Scotland small business advice service[94], which had a small business focus. After several years focusing on domestic energy efficiency whilst in a previous job at the Energy Saving Trust, SMEs appeared to have similar socio-technical issues to overcome to reduce energy demand but with added complexity. For example, energy use underpinned fundamental activities linked to organisational success and there were more complex social structures involved than in households (e.g. owners, managers, staff, supply chains). Prior to exploring the ND sector I had, perhaps naively, made general assumptions such as; that organisations had broad economic, profit making goals which should mean that they would have an interest in managing energy effectively and that seemingly obvious, cost-effective energy efficiency opportunities would be actively taken up. However, it became apparent from being part of the above-mentioned projects that what actually was occurring was very different and particularly so within SMEs. It appeared that it was extremely hard to get them to take notice of or take up energy efficiency opportunities. As described in the

[94] This service is currently provided by Zero Waste Scotland. https://energy.zerowastescotland.org.uk/ [accessed 23-1-2022]

literature review (section 2.5), there seemed to be many issues to overcome in getting organisations to take up energy efficiency, with the exception of very large, and/or public facing organisations which had greater resources, drive and conducive organisational structures (e.g. with energy and operational managers) to make concerted attempts to reduce demand. I also experienced these issues first hand, where in the five years prior to starting my PhD I was co-owner and manager of a small consultancy business called Databuild Research[95]. The bulk of our work was conducting research and advisory work on energy and sustainability issues for Government and other clients, with a particular focus on buildings and organisations. Within this context, we as owner-managers of the business, sometimes discussed that there was conflict between the work we did and our office based practices. This was because our head office was situated in a very old, draughty and poorly insulated ex-jewellery factory building in the centre of Birmingham[96], which was virtually impossible to heat. In mid-winter it was not uncommon to find staff huddled together in one room, surrounded by small electric radiators, wearing gloves and hats to keep warm. However, when we as managers investigated these challenges, it was clear that the financial cost of energy was very small relative to earnings or other costs such as staff and rent. Furthermore, beyond simple actions like turning off the heating and equipment outside of hours; the potential available solutions were very expensive and hard to engage with. We rented our building and as a growing business we were not confident we were going to stay in the office for the long term, it therefore felt too difficult to explore options seriously (e.g. draught-proofing, insulating the building fabric). Furthermore, other than our core staff, very few people (e.g. clients) ever came to the office, so there were few other reasons why we or our landlords should invest in energy improvements (?). Interestingly however, whenever we did have important clients come up to the office, we put in a large effort to try and spruce it up. We would tidy up, purchase new plants and even come in at the weekend to re-paint and do small makeovers, to mitigate some feelings of discomfort and embarrassment about our humble, draughty and run-down offices.

Whilst this context remained was a driver for my interest in small businesses and energy, during the initial stages of the PhD I put my personal intuitions to one side and approached

[95] Now named Winning Moves Ltd https://www.winningmoves.com/.
[96] The UK's second largest city, based in the West Midlands region of England.

the selection of a topic within the ND sector with an open mind, on the basis that it felt useful to take a broad view in order to try and understand where the research gaps were and what might make a useful contribution to understanding how to improve energy demand within the ND sector.

Exploring the non-domestic sector, energy management and approach considerations

It became clear that while there appeared to be many cost-effective technical opportunities for improving demand evidenced from by a range of studies (Department for Business Energy and Industrial Strategy, 2015) there are considerable differences between organisation sizes and structures and their decision making (Lutzenhiser et al., 2002). As described in the literature review however, what these technical studies seemed to lack is understanding about what these organisations are doing which appeared to me, to be fundamental to understanding why they use energy, and by extension understanding a more realistic picture of where 'real' potential for improvements lie (Kenington et al., 2019).

The literature review showed that there are several studies which describe that SMEs differ greatly from large organisations. Within SMEs, there were also descriptions about how variable they are, but very little research has been done to explore what this variability actually looks like and how it affects energy management (Fawcett, 2010).

Janda et al (Janda et al., 2016) developed a helpful segmentation of the UK ND sector, which helps provide a typology for organisations which are 'data-rich' and those which are 'data poor', which helps to understand some of the issues at play which influence energy management, shown in Figure 48.

Figure 48: Data access and building ownership/ usership matrix (Janda et al., 2016)

Segmentation of the UK Non-Domestic Market by data access and ownership/usership	Owner Occupied	Leased Space	
		Landlords	Tenants
Data Rich (e.g., an organization with AMR and an energy manager)	A	B	C
Data Poor (e.g., an organization with legacy meters and no energy analysis)	D	E	F

This typology can help define and categorize research assumptions about the nature and distribution of commercial real estate firms and organizations with respect to energy and carbon issues. The horizontal categories recognize that there are (at least) three kinds of ownership types in the market: owner-occupiers, landlords, and tenants, each of which is subject to a different kind of legal infrastructure. The categories on the right split these three ownership types into data rich and data poor categories, resulting in a typology of six different firm types.

I then looked at both larger and smaller organisations and how they appear to differ across this typology. Large organisations tend to have specific departments with facilities and energy managers whose job it is to manage bills, which becomes viable and necessary once an organisation gets to a certain size.

However, for smaller businesses it is not viable for them to have explicit energy management functions, and so they pay less attention to it, and then seemingly take much less action to manage energy effectively. This creates a large disparity between large and smaller organisations, and given the very large numbers of SMEs in the UK (out of a total 6

million private sector businesses in the UK, 5.99 were SMEs[97]) (Department for Business Energy and Industrial Strategy, 2020a), it seems very difficult to see that the UK will achieve net zero without them, and given their relative lack of progress on energy efficiency it seems that there is much greater potential within this group to take action.

Within SMEs, there are clearly some which are much more energy intensive than others, although currently they suffer from very similar issues to less energy intensive ones (Department for Business Energy and Industrial Strategy, 2015). One of the issues which does seem to affect smaller businesses less is that whilst energy isn't centrally managed, within the overall picture of energy management, there are fewer actors, and where actions to improve energy demand seem to make sense for the businesses, they seem to be able to take action more quickly and effectively than larger organisations. What appears to be missing is understanding what makes sense for these businesses, how they operate and within that how it might be possible to influence them to improve energy management. Furthermore, whilst the businesses themselves vary in their activities, their ownership profiles (e.g. owner-managed businesses) and decision making approaches may have more commonalities, which may reveal opportunities for influence. The main issue appeared to be that this has not been researched extensively before.

Using this as a basis, I then looked into what has been learned about the effectiveness of demand side interventions. As described in the literature review, albeit there is little evidence available, it appears that take up of such interventions when they have been attempted is often low (Hampton and Fawcett, 2017, Fawcett and Hampton, 2020). What did interest me though was that, building on the 4Cs framework (Janda, 2014b) within previous research with High-street retailers, I had found that energy efficiency opportunities, which also included some commercial value to them, were prioritised (Kenington et al., 2019). So, for example, the replacement of a display refrigerated cabinet, within a fishmongers shop, which would improve the aesthetics of the fish display, held much more interest than, say, a back-office freezer. Furthermore, I also found that many seemingly effective energy efficiency opportunities were immediately rejected, for a range of context-specific reasons; which were not apparent at the outset. For example, a

[97] Total employment in SMEs was 16.8 million (61% of the total), whilst turnover was estimated at £2.3 trillion (52%) (Department for Business Energy and Industrial Strategy, 2020a)

suggestion to move a freezer outside of a warm and sunny-spot to a cooler place at the back of the shop, was rejected because customers stood next to it whilst waiting to pay, and often picked additional items out of it whilst they were there. This demonstrated a lack of understanding about the strategic value of the internal environment of retail premises, particularly how the environment within their premises has been painstakingly set up to attract in customers and get them to spend money.

When conducting this research (as a pre-cursor to the thesis) two things became clear. First, it appeared that understanding what organisations are doing and why they are doing it is fundamental to understanding energy demand and its associated management, but there is a clear evidence gap here (chapter 2, section 2.5). Secondly, just understanding what they are doing is unlikely to be insightful enough to gain a better understanding about how to improve energy demand, as we know little about how the two interrelate, particularly as energy demand is an often invisible function of many complex organisational activities (chapter 2, section 2.6).

A targeted way to research these issues together would be to conduct research around the introduction of an energy management intervention, as this would enable learning about how organisations respond to the intervention to help learn about what happens and why. There are a number of things which could be done to try and achieve this. First; some kind of experimental method might help, whereby an intervention is applied to some similar businesses and others also researched which act as a control group. This appeared to be difficult to do in practice within the context of a PhD, and also not really appropriate as many of the evidence gaps are in understanding, which doesn't lend itself well to such approaches that tend to be dominated by quantitative methods (McGivern, 2009). Qualitative, case study research of participants involved in an existing intervention would be more appropriate as it would enable in-depth exploration of responses to it. This was explored, however there wasn't a suitable opportunity available to enable this kind of research.

An alternative approach, was to utilise an Action Research approach (AR), working with an organisation developing a new intervention. Conveniently, the NDSEMIC Competition (my involvement with which is described below) was encouraging the development of new interventions, and indeed the Competition was encouraging the use of AR to help them

generate lessons from the Competition which could inform future policy development. This participative approach enables researchers to get directly involved in an intervention and observe and gather insights as well as getting involved in its development. Despite having a background of doing research previously, these primarily involved traditional (i.e. qualitative and quantitative research) methods, so the opportunity to take a different approach here was interesting and exciting, and was one of the reasons I took it up.

1.1 Document selection criteria and methodological considerations

Documents were selected based on the following criteria for their inclusion within the analysis:

Firstly, on the relevance to my research question and objectives, they should:

- Describes energy management and smart meter data
- Describes energy performance of buildings and or organisations
- Describes energy management practices relating to ND actors, particularly within retail, hospitality and small industrial small businesses
- Describes other management activities, which relate to energy management

Finally, the document sources, and whether and if so what implications this might have for its interpretation, including

- Academic documents
- Government sources
- Commercial documents

Methodologies utilised in informing the documents and their likely implications for their interpretation. For example, whether the document includes, or is based on primary or secondary research, and if so the methodologies used to support its findings, in particular whether these are qualitative and/or quantitative, how the data has been sampled and implications for representativeness and its interpretation.

1.2 Approach to communications

This section, describes the communications approach I took within the second part of my research (see section 3.5.3.4), which was informed by (Torbert and Taylor, 2008). Below I

explain each of these four parts and how I used them, giving examples within the approach design and delivery.

Framing: Framing involves explicitly stating your purpose, for example the problem that you are trying to solve. Informed by this, and also the need to explicitly link intellectual knowledge and pragmatic knowledge as a principle of PRP, I used the theoretical framework (informed by the literature and part 1) to explicitly describe my theoretical understanding of the problems of improving energy management in small ND organisations, and what this means in practice. This included describing some of the mistakes which appeared to have been made by policy makers (e.g. designing energy audits and energy efficiency solutions which had had poor take up in the past and the reasons for this).

Advocating: Advocating involves expressing a clear opinion, perception, feeling or strategy for action in relatively abstract terms. Here I explained that what appeared to be a fundamental problem was that we did not understand businesses, what they are trying to achieve, how and the challenges they faced. I also explained that without this understanding we were unlikely to be able to make much further progress, and that by participating in the project they would be able to impart valuable insights to help resolve this issue and inform Government policy and industry solutions. I then used this to explain that this is the reason why I wanted to work together with them cycles of action and reflection to diagnose, plan, take action and evaluate them over time to help produce a better understanding of their businesses and also the types of interventions, using smart meter data, which could help their businesses, not only to manage energy but also in other ways, as informed by part 1.

Illustrating: Illustrating is to put some further description or context to a story, which helps to orient and motivate participants more clearly. Here I described that I would be installing monitoring equipment, for free, within their business sites, which would enable them to get to see their energy use, which would enable us to discuss this to help inform the inquiry cycles. This would benefit them by helping them to understand their energy use better, and if they wished to, they could discuss them with me and any possible solutions which might improve their energy use. In return I would get to ask them about their business and explore this and also other ways in which the solution might be beneficial to them.

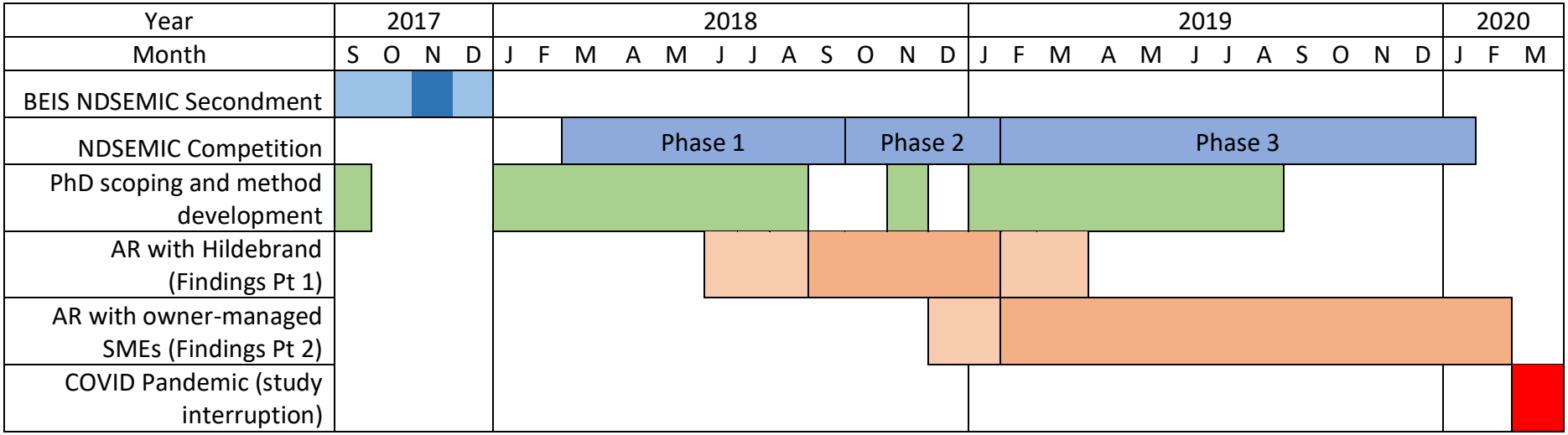
Inquiring: Inquiring is about questioning others in order to learn something from them. Torbert and Taylor suggest that we often do not give adequate change for true and honest responses, often because the previous parts of speech have not been carried out effectively either. I therefore asked whether the business owners would be happy to participate in the study and participate in a range of questioning about their business over time. In order to provide some realistic expectations I said that I would not require more than 2-3 hours of their or their colleagues time, and that I would attempt to make sure that the experience was also of benefit to them as it would be for me, as well as integrating this with their work so that I could do this alongside other activities they did (such as serving customers, for example).

Whilst this all seems quite formal as an approach, I had also learned that many in small ND are used to working in a very informal way. As such I made sure that I covered these principles and described them in as informal way as possible. This meant mainly covering these off as part of the conversation when meeting them and at the start of in-depth interviews and group discussions and including this in the information sheets and lines of questioning within the topic guides.

2 PhD Study research activities timeline

This section provides a detailed overview of the timelines associated with the main research activities undertaken for the PhD.

Figure 49: PhD study research activities timeline overview 2017 - 2020



NDSEMIC Competition activities (March 2018 – January 2020)

Secondment to BEIS Smart Metering Implementation Programme team (September – December 2017) to support the development of NDSEMIC Business case and public launch of the programme. The programme was launched via a large-scale information day, which took place on the 30th November 2017 to an audience of approximately 200 delegates, which were principally made up of technology companies, smart meter experts and other interested parties.

NDSEMIC Competition phases: The first phase of the competition focused on Competition winners developing their projects and undertaking initial development of their prototype smart meter data-based innovation tools. Nine Competition winners were selected, each obtaining a proportion of the £8.8 million of funding on offer. There was a selection stage to pass from phase 1 to phase 2, where Competition winners had to present and demonstrate the value of their proposals in order to win the rest of the Competition funding to enable further development of the project. Phase 2 of the Competition involved early pilot testing of prototype tools, including in-depth market research with involved stakeholders (e.g. SMEs in target sectors) in order to further develop their solution designs, which was undertaken in parallel with further development of a market-ready prototype testable solution. Phase 3 of the Competition involved rolling out the prototype tool to a recruited sample of target organisations to test the viability and usefulness of the solution. Alongside each phase of the Competition, BEIS funded a programme of research and evaluation to capture lessons learned across the Competition projects to feed back to BEIS policy teams and other stakeholders.

PhD Scoping and method development (September 2017 – August 2019)

Figure 49 shows the timetable taken for method development. The development of the methodology started as soon as the NDSEMIC secondment ended, as it provided me with an excellent opportunity to develop an AR based PhD, working with one of the Competition winners. I was only introduced to Hildebrand part-way during phase 1 of the NDSEMIC Competition. This was later than would have been desirable, however I was in discussions with another Competition participant project, which ended up not progressing and set my study back a few months. However, once I had met with Hildebrand and obtained their agreement to participate with their project, I was able to start working with them during phases 2 and 3 of the Competition projects.

AR with Hildebrand (June 2018 – March 2019)

Phase 2 of the Competition aligned with their activities to pilot test their GlowPro prototype, and this enabled me to develop the PhD method to engage with their research and interviews with shopping centres, energy consultants and security and cleaning contractors. The outputs of this work is described in Chapter 4 of the thesis. I was

introduced to the Hildebrand team in June 2018 and met with them on several occasions to get to know the team and negotiate my involvement with the team to do AR with them for phase 2 of the NDSEMIC Competition. As I had been involved with BEIS in developing the NDSEMIC Competition the team were interested in involving me with their project as I would likely be able to help them to understand BEIS's wishes for the Competition project from my internal experience working with the team who designed the project. In return for helping them with this, they agreed to allow me to help support their research, which would benefit my PhD and also help them with the research requirements of the second phase of the Competition project. Between October 2018 and January 2019, I worked with them very closely to design and deliver AR activities described in part 1 of the findings (Chapter 4). During this time I visited their offices or met with them on an outreach face-to-face interview (e.g. at one of the shopping centres) at least once a week, and spoke with them on the phone two or three times a week. What was challenging at this time was to balance commitments for BEIS to deliver specific in-depth interviews with different stakeholders and to align this with the AR methodology I was undertaking working with Hildebrand

AR with owner-managed SMEs (December 2018 – February 2020)

The research under I undertook with the three owner-managed SMEs aligned with the timescales of the final phase of the NDSEMIC Competition. I worked much more independently of Hildebrand during this time, however I provided Hildebrand with outputs from this research, which went on to contribute to the commitments they had to undertake during this final phase. This phase focused on rolling out the GlowPro prototype to approximately 50 SMEs, of which my sample contributed towards this target number. Hildebrand did not undertake much in-depth research with the other 47+ organisations they rolled GlowPro out to, so the outputs from my research contributed significantly to the insights they were able to report to BEIS and the NDSEMIC Competition managers. As described in the methodology (Chapter 3) I undertook two cycles of inquiry with the owner-managed businesses, including initial site visits to premises to install GlowPro monitoring equipment, semi-structured interviews with owner managers (x2) and further interviews with premises managers.

I had wanted to continue the relationships with the owner-managers a little bit longer, however my ability to undertake fieldwork on-site with the businesses was curtailed in

February 2020 due to the COVID pandemic. At this point I had to pause my research studies for almost a year in order to provide caring responsibilities for my family during the pandemic. I undertook some data analysis during the pandemic, but only really started this after schools fully re-opened and I could re-start the PhD.

Subsequently, I finished data analysis during 2021. I started writing the thesis in late 2021 and finalised this by November 2022.

3 Appendix: Information sheets and consent forms

3.1 Information sheet

Information sheet for Participation in Energy management action research

You will be given a copy of this information sheet.

UCL Data Protection Reference No Z6364106/2019/01/06

Project Title: Digital ecosystem for energy management

Invitation and project details: My name is David Kenington, and I am inviting you to take part in this research project to inform the development of a new digital ecosystem for energy management (GlowPro), working in partnership with Hildebrand and our consortium partners LoveExperience (loveexperience.co.uk), Freerunner (freerunr.com), Gengame (gengame.co.uk), and the University of Salford (www.salford.ac.uk).

This project is being undertaken as part of BEIS's Non-Domestic Smart Energy Management Innovation Competition (NDSEMIC). The project is developing an easy to use (across a range of user roles) digital ecosystem for energy management that will engage and support retailers and hospitality organisations within shopping centres and high streets, delivering a positive impact on energy efficiency, energy procurement and operational management. The research is also contributing to the fulfilment of academic research (PhD) within UCL, which is funded by the UK Engineering and Physical Sciences Research Centre (EPSRC).

Before you decide to participate it is important for you to understand why the research us being done and what participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Do ask if there is anything that is not clear or if you would like more information.

I very much hope you are interested in taking part. Participating in the project should help us develop energy management tools, which deliver our and BEIS's collective goals.

What is the purpose of the project? To help design smart meter data based energy management tools which can benefit businesses by helping them to better understand their energy use and identify opportunities for improving energy efficiency and other operational benefits.

Why am I being invited to take part? As you are involved as one of the leading partners of this competition project, you are key to the success of the project. As such, we will work together closely both conducting research and responding to insights which inform the development of GlowPro.

What will happen if I choose to take part? We will work closely together, designing and conducting research with target users (retail and hospitality businesses and other interested actors), synthesising and analysing outputs to inform development activities to further progress GlowPro. We will be involved in various in-depth discussions and working sessions between now until the project is completed (January 2020). Details of these activities are documented within our bid successful for phases 2 and 3 of the BEIS NDSEMIC Competition. As described in the Non-Disclosure Agreement (NDA), signed between us on the 1st October 2018, you will be asked to share commercially sensitive information as part of the project and my use of that information is subject to restrictions within the NDA. Given the varied and frequent nature of our interactions over the project, it is difficult to precisely determine what aspects of our interactions will contribute to the research and which will not, so it would be pragmatic to assume that all of our interactions may contribute to the research. As our work is subject to the aforementioned NDA, I will need to seek your agreement for reporting which involves interactions between us and information shared by you.

Will anyone know I have been involved? Any information that you share will be kept confidential and stored securely, in accordance with the UK Data Protection Act 2018. Neither you nor your organisation will be identifiable in any report resulting from this work, unless otherwise agreed with you. Notwithstanding this, it is an open choice for you to decide whether you or your organisation wish to be reported

anonymously or not. Given the nature of the research it may not be feasible to fully anonymise outputs, so this will be discussed with you during the project. This should be a company-level decision, as it is unlikely to be feasible for individual staff to decide whether the company remains anonymous or not. It is not intended that individuals within Hildebrand will be identified, however as we are working together as a small team, the contributions of individual members are likely to be recognizable to colleagues. As our work is subject to a Non-Disclosure Agreement, I will need to seek your agreement for any reporting done which involves interactions between us, and this includes the approach taken regarding anonymity. We will also protect the anonymity of other participants involved in our research through separate information sheets and consent forms.

Could there be problems for me if I take part? During the project, I will be party to confidential information about the project and there is a risk of harm to Hildebrand and partners should such information be disclosed to others. We have a have a Non-Disclosure Agreement (NDA) to mitigate for this risk.

What will happen to the results of the research? The results of the research will be used to inform the further development of energy management tools, as part of BEIS's NDSEMIC project. There is a possibility that the outputs of the research may be published in one or more academic journals and/or shared with Government officials to inform UK energy policy. Neither you nor your organisation will be identifiable in any report resulting from this work, unless otherwise agreed with you.

Any information that you share will be kept confidential and stored securely on our data servers, in accordance with the UK Data Protection Act. Your data will only be accessible to me and UCL research colleagues. After the data has been fully anonymised, it may be published in accordance with EPSRC guidance. You are free to opt out of this publication if you wish. If you wish, you can see a copy of this before it is published so you can check that it is fully anonymous. Additionally, I will discuss the project only in general terms, and without identifying you, to people that we mutually know.

Do I have to take part? It is entirely up to you whether or not you choose to take part, and you can withdraw at any time. It is particularly important to make this clear as we already know each other in a professional capacity, so it is important that you

do not feel any pressure to participate because of our existing relationship. If you withdrew from this research, it would also not have any effect on the other work we do together which does not contribute to this research.

If at any point you feel uncomfortable about taking part, and it may help to discuss participation with someone other than me, please feel free to contact my supervisor Paul Ruyssevelt (contact details below). You may contact him if you wish to withdraw at any point, and you do not have to give any reasons for doing so.

I hope that if you do choose to be involved then you will find it a valuable experience. There will be no negative repercussions should you choose not to participate for you, or for me as the researcher.

Complaints

If this study has harmed you in any way or if you wish to make a complaint about the conduct of the study you can contact UCL using the details below for further advice and information:

UCL: [redacted]

Phone: [redacted]

Data Protection Privacy Notice

Notice: The data controller for this project will be University College London (UCL). The UCL Data Protection Office provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk. UCL's Data Protection Officer can also be contacted at data-protection@ucl.ac.uk**.**

Further information on how UCL uses participant information can be found here:

https://www.ucl.ac.uk/legal-services/privacy/ucl-general-research-participant-privacy-notice

Your personal data will be used for the purposes outlined in this notice. The categories of personal data used will be as follows:

Name

Work email address

Work address

Work telephone number

The legal basis that would be used to process your *personal data* will be performance of a task in the public interest.

The legal basis used to process *special category personal data* will be for research purposes.

Your personal data will be processed so long as it is required for the research project, which is until December 2020. If we are able to anonymise or pseudonymise the personal data you provide we will undertake this, and will endeavour to minimise the processing of personal data wherever possible.

You have certain rights under data protection legislation in relation to the personal information that we hold about you. These rights apply only in particular circumstances and are subject to certain exemptions such as public interest (for example the prevention of crime). They include:

- The right to access your personal information;
- The right to rectification of your personal information;
- The right to erasure of your personal data;
- The right to restrict or object to the processing of your personal data;
- The right to object to the use of your data for direct marketing purposes;
- The right to data portability;
- Where the justification for processing is based on your consent, the right to withdraw such consent at any time; and
- The right to complain to the Information Commissioner's Office (ICO) about the use of your personal data.

If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at data-protection@ucl.ac.uk.

If you remain unsatisfied, you may wish to contact the ICO. Contact details, and further details of data subject rights, are available on the ICO website at: https://ico.org.uk/for-organisations/data-protection-reform/overview-of-the-gdpr/individuals-rights/

Thank you very much for taking the time to read this information sheet.

If you have any further questions before you decide whether to take part, you can reach us at [redacted]

3.2 Informed consent form

CONSENT FORM

Informed Consent Form for Digital ecosystem for energy management research

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Project: Digital ecosystem for energy management research

This study has been approved by the UCL Research Ethics Committee (Project ID Number):

Thank you for your interest in taking part in this research. Before you agree to take part, the person organising the research must explain the project to you.

If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you to decide whether to participate. You will be given a copy of this Consent Form to keep and refer to at any time.

Participant's Statement (*Please cross out any elements you are not comfortable with from the list below*)

I

- confirm that I have had the project explained to me and have had the opportunity to ask questions.
- understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline.
- consent to the processing of my personal information for the purposes of this study.
- I agree for interviews and discussions to be recorded if appropriate, and that I will be able to give or deny permission for recording freely when asked at the start of any session. I understand that the audio recording made of this interview will be used only for analysis and that extracts from the discussions, from which I would not be personally identified, may be used in any conference presentation, report or journal article developed as a result of the research (subject to the limitations of the Non-Disclosure Agreement we have between us). I understand that no other use will be made of the recording without my written permission, and that no one outside the research team will be allowed access to the original recording.
- I agree that my anonymised data will be kept for future research purposes such as publications related to this study after the completion of the study.
- understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 2018.
- agree that the research project named above has been explained to me to my satisfaction and I agree to take part in this study.

Participant name:

Signed: Date:

Researchers name:

Signed: Date:

4 Appendix: Discussion guides (examples)

4.1 Part 1 discussion guide example (Hildebrand-led)

GLOWPRO

Shopping Centre Operations Manager Discussion guide

Format	
Welcome	5 mins
Context questions	10 mins
Role tasks	10 mins
Core questions	10 mins
Debrief	5 mins
Wider strategy discussion	15 mins

Welcome

Thanks for meeting me today. We're always trying to understand how to improve our service, and getting your input is a really important part of that.

This interview will be pretty informal. I'll ask a lot of questions, but I'm not testing you – I'm actually trying to understand how you go about things. We have a couple of wider industry questions, we'll chat about those separately for 15 mins.

I'll start by asking some background questions, then I'll ask you to talk about how you go about your job. There's no right or wrong answer – just an honest account of what really happens.

As explained in the scheduling call we're a group of energy experts are working on a six month project to develop products and services to help reduce energy demand in the commercial space.

The goal is to save businesses money, improve their energy efficiency and ability to plan. Previous Smart Meter benefit work has all focussed on the home (remember Leccy and Gaz?), now we need to explore how smart meters will benefit non domestic organisations.

BEIS (the Department for Business, Energy and Industrial Strategy) have asked Hildebrand to make sure businesses with Smart Meters get the maximum benefit.

Is it okay to record and takes notes of our session? Please sign our nondisclosure form.

Do you have any questions before we begin?

Context questions

- How long have you been doing this job?
- What did you do previously?
- ~~What do you do when you're not working?~~

Monday, 12 November 2018

Jonathan Lovatt-Young
jlovattyoung@hildebrand.co.uk

- ~~How long does it take to travel from home to work?~~
- ~~How long have you lived in your home?~~
- ~~Do you have a smart meter there?~~
- Have you seen an energy in home display or used an app? Is so, which one?
- What did you want them to do for you? What do you like or dislike about them?

Role tasks

- What is the most important task you do each day?
- Who do you speak to the most each day?
- What are your daily, weekly and monthly energy tasks?
- Of these which do you think is most important?
- What systems do you use?
- What reports do you create for the General Manager?
- Are you involved in the redevelopment opportunities and use of data to support planning applications?
- How do you work with your Property Director to procure energy suppliers?
- How often do you meet tenants to discuss energy consumption?
- Do you get pressure from tenants to reduce communal costs?
- Are you looking at other energy sources to lower your carbon footprint?
- How do you schedule maintenance?
- How do you monitor maintenance activity and energy performance?

Core questions

- How do you report usage data to your Property Directors for billing?
- Do you analyse communal energy performance?
- Do you compare this with other shopping centres?
- Do you use any platforms to see energy usages across the whole site including central energy plants?
- Do you use sub-meters for zones to produce accurate bills, or rollup all?
- Do you use any analytics or benchmarks to provide insight to your tenants to enable them to improve their energy performance?
- Do you understand through analytics the breakdown of load throughout the day for new energy investments

Debrief

You talked about [topic] being something that is not great for you. If you had three magic wishes to create a service for your own needs, what would they be?

We're meeting with a number of people from organisations right down to hands-on maintenance people, once we've understood the birds eye view from everyone we'll be creating our system.

You'll get a first look at it and opportunity to tell us what you like and don't!

Thanks for your time today, if you are interested in being involved in the project going forward, please let me know as you'll get a first look at it and opportunity to tell us what you like and don't!. Before I say goodbye, can I ask if we needed to ask you another question, would you be open to either a short followup call or email?

4.2 Part 2 discussion guides (examples)

Discussion guide – general template for SME owner/manager and premises manager discussions (initial exploration of role and introduction to electricity monitoring equipment)

Discussion guides were developed for each stage of the project, building on previous insights, and tailored according to the nature of the discussions and developing relationship between the participant and I. The idea was to use the guide to make sure I had covered a range of areas I wished to explore, to support analysis across participants and interviews. However, I also wanted to keep the conversation open and flexible, so I avoided reading out the same questions in the same way and would vary the order of them, depending on how the conversation flowed. Quite often, new and unexpected issues would come up, which if I felt them interesting and relevant to the research, I would allow the conversation to deviate as needed. However I kept an eye on the discussion guide throughout to ensure that I struck a sensible balance between consistency and tailoring (Patton, 2002).

As the discussions were usually undertaken at the participants premises, part of the discussion often involved a 'walk around' of the site, so they could show me things and introduce me to other members of staff as needed. I sought permission to take photographs as part of this activity in order to capture images of relevant things within the discussion to further aid analysis.

Interview start

General introduction to the project, researcher, data recording and confidentiality.

Background and role

- How long have you worked here?
- Could you tell me a bit about your background and how you came to this role?
- Could you tell me about your current role, including what you do and your responsibilities?
- Wider team – how many work at this premises? Could you give a brief overview of what they do?

Daily operations

- Understanding what happens on a typical day – so e.g. when you open up / start the day, key activities during working hours and then what happens when you close. Note - If we can do that as part of a walk around of the site, then that would be great – but whatever works best for you.
- *Focus on activities which involve use of energy (e.g. operating energy using equipment), ensuring a focus on the service the activity provides, as opposed to explicitly talking about energy use*

<u>Managing the internal environment</u> (and if relevant external – e.g. terrace, or outside space)

- Exploring what you do to manage the internal environment and any issues you have – e.g. does it ever get too hot or cold?
- If so, what do you do to manage the environment?
- *Explore other aspects of the environment, such as the lighting, and whether and if so how they seek to maintain the aesthetics or ambience – exploring particularly for customer facing sites, what goes into making the premises welcoming and attractive to customers*

<u>Managing business performance</u>

- How you manage the performance of the business,
    - both day to day
    - and over time
- what key things you look at, and what challenges do you have?
- How do you know whether things are going well? And also identify if there are performance issues?

<u>(if applicable) Introduction to GlowPro energy monitoring system</u>

- Show participant the hardware and explain what it will be monitoring

- Introduce that I would like to have a follow up discussion, exploring the business and premises in more detail, where I will also introduce them to the GlowPro prototype and give them access to use it if they wish to

Summary and any other issues

- Make arrangements for next visit (if applicable), and also contacts for discussions with other staff as necessary
- Thank them for their help and time, and look forward to the next conversation (if applicable)

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