The social dimension of smart-grid systems: An investigation into residents' perceptions of smart-grid technologies on the Isles of Scilly

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Declaration of Originality

Declaration

'I certify that this is my own original work (unless otherwise specified) and does not exceed 10,000 words (excluding tables, references and appendices)'

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Abstract

With the UK government beginning to embrace smart-grid technology (SGT) as a means to transform inefficient energy infrastructure, questions remain around whether consumers will adopt this new technology. The technological aspects of these advanced systems are well understood, however, the social dimension of the smart-grid remains comparatively understudied and its importance unknown. Using the Isles of Scilly (IOS) as a case study this dissertation aims to examine rural consumers' motivations and barriers to the adoption of smart-grid technology. Another focus of this paper is to establish whether there are perspective differences between population groups and how location can influence consumer perceptions. The research adopts a mixed methods approach - predominantly using questionnaire and telephone interviews - guided by an aUTAUT2 framework (adapted Unified Theory of Acceptance and Use of Technology 2) to gain the views and opinions of IOS residents. Statistical and qualitative analysis reinforces the importance of financial factors in consumer socio-environmental decision-making but also highlights how a range social factors may be of greater influence. Furthermore, statistically significant perspective differences are revealed between population groups varying in age and SGT experience. Additionally, there are motivational differences (in relation to the adoption of SGT) between residents located on the off-islands of the IOS and those located on the largest island, St Mary's.

Acknowledgements

I would briefly like to thank all those who played a part in this dissertation research. Thank you to all the Isles of Scilly residents who gave their time to complete the questionnaires or participate in the interviews. Furthermore, a big thank you to all the staff at ‘Mumford’s’ paper shop on St Mary’s which acted as a collection point and allowed residents to obtain physical questionnaire copies for this research. Additionally, thank you to the Hitachi representatives who allowed me to attend a forum about the ‘Smart Islands’ project and for answering any context questions I had about smart-grid implementation on the Isles of Scilly. Above all I must thank my supervisor Prof. Richard Cowell for putting up with my relentless emailing, directing me in the right direction, and providing me with constructive feedback and guidance. Sincerely Richard, thank you.

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List of Tables, Figures and Abbreviations

Key Abbreviations

SG = Smart-grid

SGT = Smart-grid Technology

aUTAUT2 = adapted Unified Theory of Acceptance and Use of Technology 2

IOS = Isles of Scilly

(Other abbreviations are defined within the dissertation)

1

Introduction

1.1. Introduction to the Study: Context and Relevance

Whilst there is no unanimous definition for a smart-grid (SG) system, it can be described as ‘an electricity supply network that uses digital communications technology to detect and react to local changes in usage’ (Oxford Dictionaries, 2018). These systems have gained increasing attention as a means of improving energy efficiency and dispersal within electric networks. In a UK context, smart-grid technology (SGT) has recently become relevant with the government planning to implement smart meters in 26 million homes by 2020 (Smart Energy GB, 2016). According to the IET this infrastructural movement has arisen from a ‘decarbonisation agenda’ (2013:3) within the UK.

Despite governmental and organisational bodies advertising the economic and environmental benefits of SGT extensively some studies suggest that this infrastructural transformation, and SG projects in general, have been met with consumer resistance (Sovacool et al; 2017). This could stem from social factors involved within SG adoption being overlooked in policy and academia (Wolsink, 2012; Balta-Ozkan, 2013; Sovacool et al; 2017). The technological elements of SG systems have been researched thoroughly in engineering and computing disciplines. Additionally, regulatory issues and market restrictions have also been discussed (Xenias et al, 2015; Connor et al, 2018). However, factors that both encourage and restrict consumer adoption and perceptions remain comparatively understudied. Given the socio-technical nature of SGs, human interaction is essential for the systems to function properly (Shin, 2014). Therefore, it is important to research the factors both preventing and incentivising adoption/interaction so the widespread

environmental and economic benefits of these unique systems can come to fruition.

1.2. The Research Aims and Questions

The research aims were principally set to understand consumers' perceptions of SGTs and the push and pull factors associated with the adoption process. Additionally, the aims and subsequent questions looked to fill a current research gap by discovering whether there were perspective differences between population groups and to what extent geographical location influences socio-environmental decision-making. Table 1.1 outlines the research aims and questions.

Table 1.1: Research Aims and Questions

Aims	Research Questions
1. To understand the main factors influencing and restricting the adoption of smart-grid technology on the Isles of Scilly (as perceived by residents)	*RQ1: What are the principle positive motivations for residents' adoption of smart-grid technology on the Isles of Scilly?*
	RQ2: What are the main perceived barriers to residents' adoption of smart-grid technology on the Isles of Scilly?
2. To assess whether specific population groups (defined by levels of income, household population, age and experience) present differences or associations between residents' perspectives of smart-grid technology on the Isles of Scilly	*RQ3: To what extent do residents' views of smart-grid technology implementation on the Isles of Scilly present differences or associations between specific population groups?*
3. To assess the role of geographical location (defined by island of residency) in the adoption of smart-grid technology on the Isles of Scilly	*RQ4: To what extent are attitudes towards smart-grid technology adoption effected by geography and location on the Isles of Scilly?*

1.3. Dissertation Structure

This dissertation consists of 5 chapters. Following this introduction, a critical review of existing literature examines: the academic landscape of SGT,

the current research gaps, and relevant theoretical frameworks. Chapter 3 provides contextual information related to a case study approach and outlines the research design. Chapter 4 forms the bulk of this dissertation, it analyses the data collected and builds upon existing literature. Finally, Chapter 5 presents a conclusion for this dissertation and briefly discusses the limitations of this project and future research avenues.

2

Literature Review

2.1. Introduction to the Review

The literature review of this dissertation will examine published work on relevant theories, issues and areas of study surrounding the social dimension of SGT. The review will firstly discuss how a global low-carbon transition has become necessary due to the effects of climate change. Following this, the text will identify how a strand of literature within energy geographies has started to focus on low-carbon transitions. The next segment will discuss the use of socio-technical systems, within energy transformations, and how the social dimension of SG systems is often overlooked. Following this the social barriers to SGT adoption are discussed, along with consumer motivations. Finally, the literature review will touch upon relevant theoretical models and identify the most appropriate for this dissertation research.

2.2. Climate Change and Energy Geographies

Since 'The Changing Atmosphere' conference held in Toronto, along with the subsequent formation of the Intergovernmental Panel on Climate Change (IPCC) in 1988, 'global warming' has been deemed a major political issue (Paterson, 1996). Numerous international treaties have been constructed such as the Rio Convention, Kyoto Protocol and most recently the Paris Agreement which aims to 'strengthen the global response to the threat of climate change' (UNFCCC, 2018). Additionally, publications such as the IPCC's special report (2018) and increased social media activity have resulted in energy policy taking centre stage in the contemporary geopolitical landscape. The increasing awareness of climate change from citizens and the scientific research that has confirmed humans are the cause (IPCC, 2007) has led to a

global consensus, demonstrated through the aforementioned treaties, that a worldwide low-carbon transition is necessary.

2.3. Low-carbon Transitions and Rural Neglect

Academic literature has developed parallel to the increasing emphasis placed upon energy policy within the political landscape and social media. In spatial-science energy geography or 'geographies' (Calvert, 2015) are not new areas of research. However, they have experienced significant awakening within recent years due to the previously mentioned contemporary context where 'energy debates are at the forefront of key societal challenges and transformations' (Luque-Ayala, 2016). In line with the general understanding that a global transition is required, low-carbon energy transitions have become popular areas of research within energy geographies. Geographers have focused on the implementation of new technologies, the social dimensions of low-carbon transitions, and how they are governed (Bridge et al, 2013; Geels, 2012; Verbong and Loorbach, 2012). Additionally, academics have researched the spatial dynamics of low-carbon energy transitions and used frameworks to examine the theoretical nature of national transitions, most notably the Multi-level perspective (MLP) (Geels, 2012; Geels, 2014).

With case studies across the globe, and the multi-disciplinary nature of transition processes, the literature on low-carbon transitions is abundant. However, the majority of transition literature is generally related to infrastructure transformation in urban areas (Bulkeley et al, 2010; Bulkeley et al, 2013; Golubchikov and Badyina, 2012; Hodson and Marvin, 2012). This urban focus is perhaps unsurprising when considering the clustering of economic activities and population density. Similarly, from a UK policy perspective, there has historically been little focus from the government on rural energy transitions. Admittedly, recent governance has taken the advice of certain bodies (such as the RTPI, TCPA, ACRE) that believe policy should 'steer local plans to permit acceptable small-scale renewable energy developments in the countryside' (The Rural Coalition, 2010:8). However, the installation of renewable energy facilities has not created a systematic change in the energy consumption of rural populations. Another reason for the neglect of rural

transitions, in governance and research, may be down to 'the heterogeneity of rural geographies' (Sherry-Brennan and Pearson, 2015:23) and that this diversity has been 'inadequately expressed in new theoretical frameworks' (Van der Ploeg et al, 2008:1). Rural areas are often unique in terms of their socio-economic and demographic composition which makes it hard to compare transitions through an ideological perspective that applies to all rural regions.

However, this lack of engagement can no longer be ignored. With the government promoting the decentralisation of energy systems, it remains unclear how this will affect rural areas which make up 30% of the population (DEFRA, 2014). Furthermore, the benefits of past UK rural projects have been varied with some 'proved unsuccessful resulting in skepticism as to their effectiveness and practicality' (FREE, 2011:6). From a socio-geographical perspective this leaves questions surrounding the 'willingness of rural-communities to plug-into the complex… systems of energy development' (Frantál and Martinát, 2013:10). These systems of energy development generally consist of both social and technical elements with human adoption and interaction being a necessity for effective functionality. As such, it is important to understand rural consumers' socio-environmental decision-making to direct policy-makers and subsequently ensure the up-take of these systems in rural areas.

2.4. The Ignored *'Social'* in Smart-Grid Technology

SG infrastructures relate to systems of energy development and can be characterised by the concept of socio-technical systems. A socio-technical system essentially involves complex interactions between humans, machines and environmental aspects of the work and living systems (Baxter and Sommerville, 2011:5). According to Badham et al (2000) socio-technical systems generally have five key characteristics: interdependent parts, the ability to adapt in external environments, an internal environment including interdependent technical and social subsystems, equifinality, and performance reliant upon the optimisation of technical and social subsystems. Fundamentally, the most important part of understanding a socio-technical system is realising the interplay of the 'social' and 'technical' dimensions - if

one excludes the other the potential of the system may not be fulfilled. A SG is a type of socio-technical system. It can be defined as a concept that 'integrates information and communication technologies (ICT) with grid power systems, in order to achieve efficient…energy generation and consumption. It is characterised by a two-way flow of both electricity and information.' (Risteska Stojkoska and Trivodaliev, 2017:1455).

SGT is an area of study in which the technological aspects have been researched greatly from disciplines such as computing, engineering and software design. However the human dimension of SGs, or the *social* dimension of this technical system, is comparatively understudied. This lack of knowledge may be an issue considering that the smart grid is 'being deployed and implemented much faster than we are able to fully consider its implications' (Blumsack and Fernandez, 2012:61). Additionally, research stemming from technical disciplines tends to consider consumers in simplistic terms, identifying publics as economically rational or predictable, and UK policy echoes this trend. This is despite limited research from social studies highlighting consumers as irrational (Cherry et al, 2017:40) or habitual (Maréchal, 2010), through ideals such as Social Practice Theory (Shove et al, 2012), in the face of new technologies. This area of research must grow to inform policy-makers of the complexity, and individual agencies, within socio-technical systems. This area of research has become relevant due to the government planning massive change in relation to UK energy infrastructure.

The UK energy sector is under-going drastic change with one of 'Britain's biggest national infrastructure projects in decades' (Vaughan, 2018) and very significant claims are made for this scheme. This refers to the government planning to install smart meters, in 26 million homes by 2020 (Smart Energy GB, 2016), and starting numerous joint-ventures focusing on the implementation of SGT. Economically, SGT could save consumers £6.43 billion (Jenkins et al, 2015:419) and the government estimates the total benefits by 2050 to be between £17-40 billion (Ofgem, 2017:5). SGT would also help to cut emissions in the UK through intelligent energy dispersal and communication. Additionally, a report by Hodges et al (2016:21) for the Eaga Charitable Trust suggests that switching to smart prepayment meters (PPM) could save up to

181,000 households from fuel poverty by 2020. However, all these projections are predicated on SG systems (and components) working as effective socio-technical networks and consumers enacting the necessary behaviours (Goulden et al, 2014). Whilst a number of issues have been identified within the UKs market structure and regulatory framework (Xenias et al, 2015; Connor et al, 2018) a key area many believe has been over-looked are the social factors effecting consumers' decision-making in relation to the adoption of SGT.

2.5. Social Barriers and Motivations

Energy geography has been one of the few disciplines that has examined the importance of social issues in socio-environmental decision-making. However, when relating specifically to SGT only a 'few studies [have] examined challenges facing the industry or, specifically, social aspects of smart home technology adoption and diffusion' (Balta-Ozkan et al, 2013:364). Within this broad lacuna there are a few pioneering works which have made significant contributions by stating the importance of social research, in SGT, and identifying potential areas of research.

Wolsink (2012) highlights the vague legalities of SGT by discussing issues surrounding: system boundaries, ownership, access rules and compliance rules. These areas of study relate to the ambiguity of information that is found within SGT projects. In some schemes it is still fundamentally unclear who owns the energy at what points in time, and where, in the journey around the smart-grid cloud. Additionally, rules associated with compliance are often unclear (Wolsink, 2012:831) within SGT projects, for example what happens if a user suddenly loses internet connectivity and is unable to input the required data within a given time frame. Whether these aspects are potential barriers for consumers, or whether consumers have knowledge of this uncertainty, is a newly emerging area research.

Perhaps the most practically engaging research, purely examining the social barriers to SGT, has come from Balta-Ozkan et al (2013). They conducted a number of workshops which found six key social barriers to the public's adoption of SGT: loss of control, reliability, privacy, data security, cost,

and trust (2013:369). Additionally, other studies have highlighted the importance of detail to consumers showing that if information is presented poorly through an interface, or withheld from the consumer, unexpected behaviour can occur (Losi et al, 2015). However, more research is required to give weight to these findings and question whether there are more barriers, if so which ones are more or less important to consumers and how can this help direct policy.

The role of demographics in the adoption of SGT is another area of research which is limited but growing. Certain studies have addressed how age can directly or indirectly play a factor in the adoption of smart and renewable technologies (Mills and Schleich, 2012; Anderson et al, 2012). Barnicoat and Danson concluded, in their study examining the perspectives of elderly people on SGT in Scotland, that 'many older people across the UK show no wish to switch and have little knowledge of smart technology' (2015:114). This conclusion suggests a potentially significant issue to the adoption of SGT in the UK where, due to developments in healthcare and lifestyle, approximately 20% of the population is over age 65 (ONS, 2017) and this percentage is rising. Besides the aforementioned studies, the role of age in the adoption of SGT is relatively understudied. As a result, there are questions surrounding why elderly people are less likely to adopt SGT and, in a wider sense, whether different population groups associate with different barriers.

Moving beyond age-demographics, the cultural norms and identity of certain populations may also be an underlying factor in the adoption of SGT. Wolsink (2012:828) discusses how concepts such as 'place attachment' and cultural connections may play a very important factor in the adoption of SGT, however in terms of practical proof and empirical research the literature regarding this is minimal. Although it could be argued that, despite a lack of practical research, the explanatory role of place attachment and spatial-influence has been highlighted by key academics. Most notably Devine-Wright (2009) discussed the role of place attachment and the 'NIMBY' concept in relation to place-protective action. Whilst many academics do accept that for a localised low-carbon transition to be successful cultural norms and identities must evolve (Snape et al, 2011), the details of these norms and extent to which

identities remain permanently embedded remains vague. Also most literature in this area has examined place in relation to public responses to visually disruptive technology, such as wind turbines, not in relation to less visible reorganisation of energy systems. Ultimately, this socio-spatial lacuna leaves questions surrounding the role of location, and place identities, in the consumer adoption process.

Inherently linked to social barriers, it is also important to understand what social motivations direct consumer adoption. There is a wide consensus in literature that generally points to economic motivations being the most appealing (Paetz et al, 2012:37; Mert et al, 2009) for the adoption of SGT. Verbong et al describe financial incentives as 'the best instrument to persuade or seduce the users' (2013:124). However, limited studies claim that social and socio-environmental influences are just as important. Certain studies suggest social variables such as preference, household relations and embedded routines have an important role in techno-environmental decision-making (Hargreaves et al, 2010; Hardy, 2012). Furthermore, social pressure such as consumers being recommended SGT by a friend, or even being in competition over consumption savings, have been suggested as key motivators to the adoption and enactment of SGT (Gangale et al, 2013:626; Abrahamse et al, 2005).

2.6. Theoretical Frameworks and the UTAUT2

The literature surrounding energy studies is theoretically expansive and 'a number of theories have proposed to explain consumers' acceptance of new technologies and their intention to use' (Lai, 2017:22). Consequently, there are numerous models that can be applied, or in some way altered, to provide a theoretical basis for SGT research. A few key models have received substantial empirical support for practically examining consumer behaviour (for more details see Sintov and Shultz, 2015:2). These include, but are not restricted to, the Theory of Planned Behaviour (TPB) (Ajzen, 1991), Norm Activation Model (NAM) (Schwartz, 1977), the Value Belief-Norm (VBN) (Stern et al, 1999) and Community-Based Social Marketing (CBSM) (McKenzie-Mohr, 2000). However,

the most influential model has been the Technological Acceptance Model (TAM) (Davis, 1989).

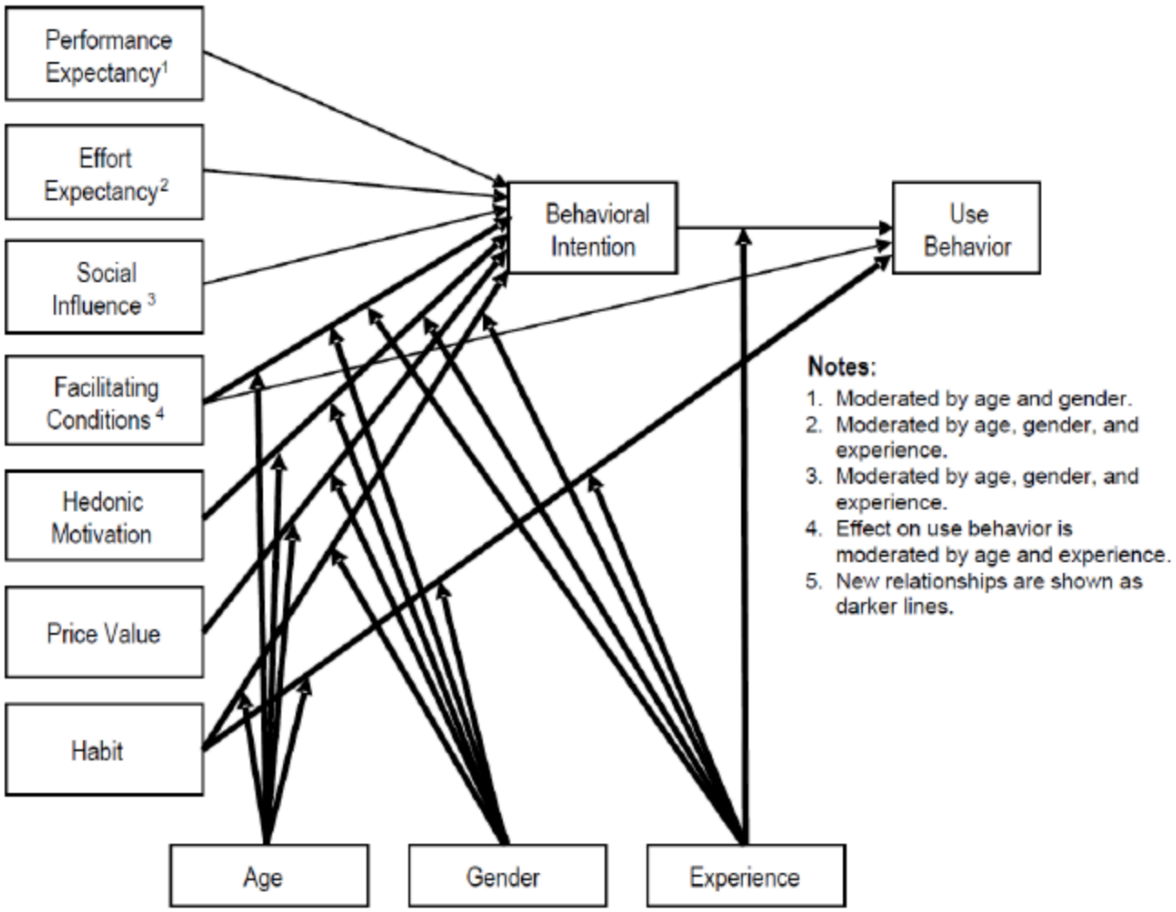
The TAM itself was originally developed from the Theory of Reasoned Action (TRA) in the 1980s and has since become a principle theory in energy studies - 'as much as 10% of the space allocated to Information Systems publications is claimed by TAM research' (Holden and Karsh, 2010:159). The framework has been praised for its parsimonious nature that 'represents the antecedents of technology usage through beliefs about two factors: the perceived usefulness (PU) and perceived ease of use (PEOU) of a technology' (Yousafzai et al, 2007:252). According to Davis et al (1989:985) PU can be defined as a consumer's 'subjective probability that using a specific application system will increase his or her job performance within an organisational context', PEOU is the 'degree to which the user expects the target system to be free of efforts' (1989:985). At it's core the TAM presumes that a number of factors, that can be grouped into either PU or PEOU, influence the decision-making of consumers in relation to the adoption and enactment of new technologies.

Despite its support the TAM has been subject to numerous criticisms. Key criticisms include: the weak theoretical linkages among constructs developed within the TAM (Bagozzi, 2007), and the models simplicity compared to more complex frameworks that provide more explanatory detail. For example, the TPB includes more independent variables and more appropriate constructs such as perceived behavioural control (Mathieson, 1991). These criticisms have resulted in continuous redevelopment of the TAM with models such as the TAM2, TAM3 and UTAUT (Unified Theory of Acceptance and Use of Technology) being created.

The UTAUT2 (Venkatesh et al, 2012) is one of the most recent models. The original UTAUT was a redevelopment of the TAM that fundamentally augmented PU and PEOU into a number of different variables and introduced moderators. The only differences between the UTAUT and UTAUT2 are the introduction of three new variables (hedonic motivation, price-value and habit),

the rearrangement of construct relationships, and the introduction of new relationships (Venkatesh et al, 2012). Fig. 2.1 shows the UTAUT2 below.

Figure 2.1: Unified Theory of Theory of Acceptance and Use of Technology 2 (UTAUT2). Source: Venkatesh et al. (2012:160)



Similar to the UTAUT the moderators of age, gender and experience are presumed to control specific variables and in-turn effect consumer intention and use behaviour. The theoretical relationships are informative and their statistical significance can be proved through specific post-hoc tests (see Venkatesh et al, 2012). In this research paper the UTAUT2 is not applied in a traditional sense, it is primarily for methodological guidance (this will be further discussed in the methodology section).

2.7. Review Summary

To summarise, this literature review has highlighted the worldwide consensus committed to a global low-carbon transition. Energy studies have developed parallel to this agenda with a focus on low-carbon transitions. The

majority of research in this area tends to be related to an urban context, more research into SGT in rural areas is required. The UK government plans to implement SGTs at an increasing rate. However, potentially influential social factors are being overlooked. Key social issues revolve around: specific barriers, age-demographics, cultural identity and/or location itself. Considering the limited literature in this area more research is required to identify whether these barriers apply to other contexts and whether there are perspective differences between population groups. Additionally, the UTAUT2 has been highlighted as an appropriate means of guidance and hypothesis articulation within this research (however this is subject for adaption - see methodology).

3

Research Design and Methodology

3.1. Introduction to Chapter 3

This section will outline the key approaches, methodologies and considerations that went into formulating this research design. The overall design adopted a positivist stance with a focus on collecting closed-qualitative data which was then coded to enable statistical analysis. Mathematical techniques are a central feature of this epistemological perspective (Carson et al, 2001). However, purely qualitative data was also collected to provide support for statistical findings and offer alternative interpretations.

3.2. A Case Study Approach

Certain academics (Wievorka, 1992; Geertz, 1995) identify how a case study approach can have subjective elements, Ragin (1992:225) recognises this as a 'special feature of small-*N* research'. However, Yin (2013) highlights how a case study approach is appropriate when there is a specific set of circumstances. The Isles of Scilly (IOS), an archipelago situated 28 miles off the Cornish coast, has just this. With almost 40% of the population on the IOS over age 55 (Urbistat, 2015) and residents located on 5 inhabited islands, this unique case study invites questions around energy differences between population groups. Furthermore, fuel poverty on the IOS is 4.1% above the national average (Local Government Association, 2016) due to many having low incomes and unreasonable heating costs (Care and Support in Cornwall, 2018). This combined with the high rurality of the region - which has been noted in 'An index of rurality for England and Wales' (Cloke et al, 1977:35) - invites questions surrounding how SGT is perceived in rural areas. SGT is being implemented on the IOS through the 'Smart Islands' programme. This project began in 2018 and aims to 'sustainably and affordably tackle…the

[IOS'] main infrastructure and utilities issues' (Smart Islands, 2018). Led by the multinational conglomerate Hitachi, this project aims to create a 40% reduction in energy bills by 2025 and fundamentally coordinate a low-carbon transition on the IOS. (Scilly.Gov, 2018). Fig. 3.1 shows a visual summary of the project.

Figure 3.1: Visual summary of 'Smart Islands'. Source: Smart Islands (2018)

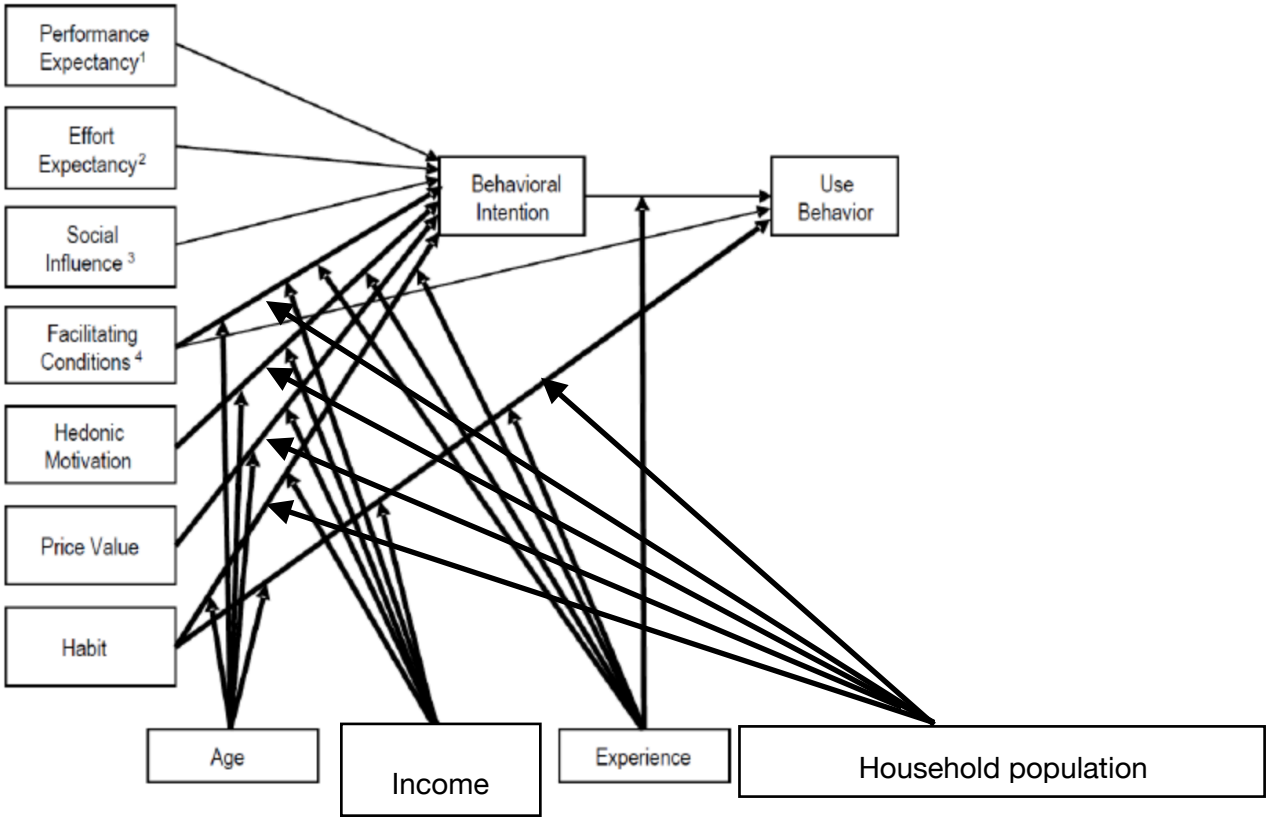
The Smart Islands programme proposes numerous additions to energy infrastructure on the IOS (Hitachi Europe Ltd, 2016:38) and a key element of this project is the implementation of the 'Internet of Things' (IoT) platform. A form of SGT that in simplistic is an 'automated communication model [in which] devices… respond to changing, dynamic circumstances' (Jabłońska, 2014:121). Additionally, Western Power Distribution (WPD) are also running a project named 'Smart Energy Isles' (Western Power Distribution, 2018). Within this project WPD will be able to offer IOS customers smart-meters (in the form of OWL monitors) to manage their household usage.

3.3. UTAUT2 Adaption

The UTAUT2 has been adapted to guide methodological elements of this research. Firstly, the moderator 'gender' was switched with a new

moderator, 'household population'. It has already been documented that techno-environmental views present gender difference (Clancy and Roehr, 2003; Davidson and Freudenberg, 1996). However, it has been noted that other factors may skew these perspectives such as marital status and household population (Dalen and Halvorsen, 2011:7). Currently, limited research has examined the perspective-influence of joint decision-making hence the addition of a 'household population' moderator. Furthermore, an 'income' moderator was added as certain studies have found high-income households are more willing to invest in energy efficiency (Ameli and Brandt, 2015). The new moderators are assumed to share similar relationships to the previous moderators. Fig. 3.2 Shows a visual representation of the adapted UTAUT2 (aUTAUT2).

Figure 3.2: adapted Unified Theory of Theory of Acceptance and Use of Technology 2 (aUTAUT2). Modified from: Venkatesh et al. (2012:160)



3.4. The Triangulation of Research Methods

Triangulation in research can be defined as 'the use of more than one approach to the investigation of a research question in order to enhance confidence in the ensuing findings' (Lewis-Beck et al, 2004:1142). There are four types of triangulation: data, investigator, theoretical and methodological

(Denzin, 1970). This research adopts a mixed methods approach and uses both data and methodological triangulation. Due to research limitations, such as cost, only one researcher undertook this investigation. Furthermore, this research draws upon a number of concepts however does not seek to test theoretical frameworks against each other, as such it could be argued this research lacks theoretical triangulation.

3.4.1. Surveys

The primary method used within this research was surveys. Surveys are defined as 'the collection of information from a sample of individuals through their responses to questions' (Check and Schutt, 2012:160). Surveys were deemed as an appropriate methodology as they are widely accepted within social research as a means of collecting descriptive, factual information (Lewis-Beck et al, 2004:1104) . Additionally, due to the IOS' small population size, 2,200 (Cornwall Guide, 2018), surveys were an effective way to obtain a relatively proportionally large percentage of views. Moreover, surveys can answer questions about the distribution of characteristics within a population (Secor, 2010:196). In this research, surveys took the form of online and physical questionnaires. Online questionnaires were chosen due to their low cost and wide accessibility (Evans and Mathur, 2005:197). A Facebook page named 'Isles of Scilly Residents' Notice Board' (IoSRNB) presented a platform to obtain a high response rate as 1198 IOS residents, approximately 50% of the population, followed the page. Online surveys also have disadvantages such as a lack of personality and not being able to reach specific groups that lack online experience (Evans and Mathur, 2005:197). To suppress these downfalls, physical copies where also available from the paper shop 'Mumford's' on St Mary's and a selection were posted to venues on the inhabited off-islands.

The survey sampling method was essentially a form of non-probabilistic random sampling. Non-probabilistic random sampling was chosen due to the ease of obtaining responses and its unbiased nature (Sharma, 2017:750). However, there was a sense of pragmatism within the sampling method that leaned towards quota sampling. From a pilot study, it was identified that the administration of paper responses was necessary to obtain more elderly

perspectives and gain responses representative of the population demographics. The pilot study took the same form of administration as the main online survey, a link being posted on the IoSRNB, however was only open for 3 days.

The questionnaires were administered over approximately 4 weeks and generated a total of 103 responses, around 5% of the total IOS population. The questionnaire content centred around nominal and ordinal data using multiple choice answers and Likert scales. Open-ended options were available for certain questions. The UTAUT2 moderators were used to place participants within population groups asking questions associated with income, experience and demographic information. The variables of the aUTAUT2 also guided specific question formulation associated with residents' motivations and barriers to SGT adoption. In this case, variables such as 'hedonic motivation' were converted into 'reduce islands energy emissions' (see appendix 1 for more details), it was thought simpler interpretations would be more appealing to participants.

3.4.2. Interviews and Participatory Observation

Interviews and participatory observation acted as supporting research methods. Participatory observation is used to examine tacit aspects of a specific cultures or groups (DeWalt and DeWalt, 2011:1). The researcher attended a forum led by representatives from the 'Smart Islands' project. The forum was held on St Agnes with an attendance of around 20 residents. This observation was required due to the infancy of SGT implementation on IOS, as such there is a general lack of contextual information from secondary sources.

Interviews were also conducted to support the statistical findings of the survey. Four telephone interviews were conducted and ranged from 10-20 minutes. Telephone interviews were deemed appropriate due to the wide geographical access and ability to contact hard to reach populations (Mann and Stewart, 2000). These interviews were semi-structured allowing for follow up questions. The interviews were phonographically recorded for transcription purposes. Filmed face-to-face interviews were considered due the

disadvantages of telephone interviews, such as the 'asynchronous communication of place' (Opdenakker, 2006:4). However, due to field-work time restrictions, these would be dependable on participants installing specific software. A convenience sampling method was used for the interviews due to the ease of data collection (Salkind, 2010). Elements of purposive sampling were also evident as it was a deliberate decision to gain responses from residents with specific characteristics: an off-island resident, residents with and without SGT installed, residents of varying age.

3.5. Analysis Methods and Ethical considerations

The results of this research were predominantly examined through non-parametric, post-hoc, and association tests along with the inspection of descriptive statistics. Nominal and ordinal questionnaire results were coded into SPSS software and purely qualitative results tested lines of explanation. The decision to choose specific tests was based on the data sets meeting certain assumptions (more detail on this in the analysis section).

Due to the nature of particular research methods a number of ethical considerations went into the formulation and undertaking of this research to ensure participants and relevant entities were in no way ethically dissatisfied. Key issues related to consent, anonymity, confidentiality and forum exclusivity in relation to the participatory observation. Table 3.1 shows these considerations and the corresponding responses.

Table 3.1: Ethical considerations and researcher responses

Consideration	Researcher response
Consent	A consent form was created for the interviewees, it outlined their rights as participants and made it clear their involvement was completely voluntary (see appendix 2). It was also made clear to participants that the consent form must be signed before any interview could take place and that the signing of this form also showed their consent to being phonographically recorded. It was also made clear in the questionnaire brief that participation was completely voluntary (see appendix 1).
Anonymity and confidentiality	Within the interview consent form, and questionnaire brief, participants were informed of the aims and reasoning of the research project, they were also informed who the information would be shared with (Cardiff University). Also within the interview consent form was the option for participants to request anonymity and a pseudonym to be used instead. Furthermore, participants could request a copy of the transcript. The questionnaires were completely anonymous and participants were informed of this.
Forum exclusivity	The forum on St Agnes was intended for residents only. To ensure there would be no issues, the researcher's attendance was checked and cleared with the relevant organisational bodies.

4

Analysis and Discussion

4.1. Introduction and Chapter Structure

This chapter aims to describe and analyse the findings of this dissertation research which revolves around residents' views of SGT on the IOS. The chapter is structured around the 4 research questions (RQ) outlined in Table 1.1 in the introductory chapter. It should be noted that the analysis of this chapter takes different forms. RQ1 and RQ2 analysis is more thematically oriented, whilst RQ3 and RQ4 take the form of a statistical report and attempt to statistically disprove null hypotheses. However, both sections still draw upon both quantitative and qualitative findings.

4.2. RQ1 - What are the principle positive motivations for residents' adoption of smart-grid technology on the Isles of Scilly?

There were two fundamental questions within the questionnaires that participants were required to answer. Drawing upon past academic research, along with variables from the aUTAUT2, these questions looked to identify the main motivations and barriers to the adoption of SGT on the IOS (refer to appendix 1 - questions 14 and 15). Table 4.1 shows the results of question 14 which related to consumer motivations to install SGT. 46.6% of the participants chose the reduction of energy costs as their main reason for the installation of SGT. As this was the highest percentage result, it could be stated that these results align with literature that concludes financial savings as 'the greatest motivation for participation' in SGTs (Wang et al, 2011:420). These results also justify the use of the UTAUT2 as a base model and its addition of the 'price value' variable as an influencing factor in behavioural intention (Venkatesh et al, 2012). The qualitative findings also supported the descriptive statistics with 3 out of the 4 interviewees declaring a reduction in energy costs was their main

Table 4.1: Descriptive results of question 14: 'What would be/ what was the main reason you installed a smart meter or smart-grid component?'

Main reason for installing SGT	Frequency of responses	Percentage (%)
To reduce energy costs	48	46.6
To reduce Island's emissions	23	22.3
To increase control of household usage	25	24.3
Recommended to by a friend, council member or organisational representative	5	4.9
Other	2	1.9
Total	103	100

incentive for installing SGTs. Vicky, a St Mary's resident age 46, identified how she was aware of the environmental benefits but a reduction in energy costs was the main reason she installed her 'OWL' monitor.

> ***Vicky**: 'I guess… to drive the energy consumption down so we can save money mainly. Obviously it is good for the environment as well but honestly if it wasn't saving me money I wouldn't have got it.'*

These results run parallel to existing research studies that have discovered monetary savings to be the most important benefit to consumers (Paetz et al, 2012:37). Similarly to Vicky, a number of open-ended questionnaire responses noted environmental benefits but were primarily interested in the financial benefits. This is a pattern seen in past research studies (Mert et al, 2009). Furthermore, question 11 asked participants whether they would remain with the same energy service if a cheaper SGT-alternative was available. Table 4.2 shows how 60.2% declared their responses 'definitely no' or 'no'. Combined with the results from question 11, it could be argued these findings support constructions of the rational resource man within SG imaginaries (Ballo, 2015:13). This high percentage is perhaps to be expected considering

residents' low income on the IOS which in 2005 was around £2000 below the national average (Dugan, 2008).

Table 4.2: Descriptive results of question 11: 'Would you remain with the same energy service if a cheaper alternative was available?'

Would you remain with the same energy service if a cheaper alternative was available?	Frequency of responses	Percentage (%)
Definitely No	28	27.2
No	34	33
Maybe	32	31.1
Yes	8	7.8
Definitely Yes	1	1.0
Total	103	100

However, these results could be viewed from a different angle. The option 'to reduce energy costs' obtained the highest rate of responses, yet it was not a majority. Furthermore, whilst the majority of interviewees did declare the reduction of energy costs as their main motive for the adoption of smart technologies, some stressed the importance of other factors specific to the IOS. For example, Vicky and Paul (a St Martin's resident, age 71, without SGT installed) highlighted the importance of social influence and the environment.

> ***Vicky**: 'word of mouth is the best way of getting things to really register with people on Scilly.'*

> ***Paul**: 'For me, the only reason I would install these new technologies is if I was sure they would decrease my pollution or output or whatever.'*

These results were intriguing considering that, despite fuel poverty on the Isles of Scilly being comparatively high to the national average, 63.4% of the participant pool did not declare a financial incentive as their main motivation. This evaluation resonates with literature that identifies 'the relatively

limited financial savings they [SGTs] can provide is not enough of a strong drive on its own' (Balta-Ozkan et al, 2013:372) for consumers. Ultimately, it is clear financial savings are a key motivator for many residents on the IOS to adopt SGT. However, for the majority it is less influential than social factors relating to: consumers' attitudes, general interests, values and comfort habits (Nyborg and Røpke, 2013:665).

4.3. RQ2 - What are the main perceived barriers to residents' adoption of smart-grid technology on the Isles of Scilly?

Acting as a reverse to question 14, question 15 aimed to identify the key social barriers to the adoption of SGT on the IOS as perceived by residents. Table 4.3 shows the descriptive results of question 15. The responses for question 15 were incredibly dispersed. As such, it could be stated, these findings present the diversity of social barriers associated with SGT adoption. This dispersal emphasises that, despite the extensive technological understanding of these new technologies, for many consumers the adoption of these new innovations still remains 'socially suboptimal' (Guo et al, 2015:36).

Table 4.3: Descriptive results of question 15: 'What would be/ what was the main reason you didn't install a smart meter or smart-grid component?'

Main reason for not installing SGT	Frequency of responses	Percentage (%)
Confusing technology	18	17.5
Satisfied with current service	13	12.6
Unclear about ownership, compliance rules and privacy regulations	18	17.5
General lack of information	17	16.5
Cost of the installation process	9	8.7
Not sure/ unknown	16	15.5
Other	12	11.7
Total	103	100

However, by combining the 'general lack of information' and 'unclear about ownership, compliance rules and privacy regulations' options, it shows these two answers shared 34% of the total responses. This combination can be justified as both responses can be categorised within the 'facilitating conditions' variable of the aUTAUT2 model, as they both relate to the knowledge and accessibility of appropriate information for consumers. These findings position with literature that claims there is ambiguity surrounding the smart-grid industry as a whole and in-particular ownership, security, and compliance rules (Wolsink, 2012; Balta-Ozkan, 2013). It seems over a third of IOS residents share this ambiguity and feel they do not have enough information about SGT. This lack of information is inherently linked with a lack of understanding and education that prevents consumer adoption. Certain academics have identified how smart-grid information must be coordinated appropriately to avoid consumer misconception or confusion (Park et al, 2014:217). Additionally, Kappagantu and Daniel identify how 'educating people about SG [smart-grid] is much essential for its acceptance' (2018:460). By collapsing the response options in relation to aUTAUT2 variables, it could be argued that these results support this literature.

The qualitative findings obtained from the interviews, and from the open-ended survey questions, suggest similar trends to the descriptive statistics. Many raised issues surrounding the accessibility of relevant information.

> ***Questionnaire participant #41****: 'Not enough information - brochure posted through door would be good'.*

However, despite sharing similar patterns, the qualitative results also highlighted residents' concerns about the financial longevity of SGTs on the IOS. The results below show comments from the 'other' option in question 15 and interview data.

> ***Questionnaire participant #32: '****Cost, limited understanding of process, outcomes for the future. What as a community will we be left*

with in future and who will cover any costs which maybe associated, could costs increase?'

***Paul**: 'If it works out well for the islands I will be happy, but honestly I just can't see how all the new stuff will be made once we leave the EU and lose their funding.'*

These findings suggest that consumers' path to adoption and their behaviour is influenced in complex ways (Mesarić et al, 2017:1465). These IOS residents highlight how 'energy consumption is not the result of quick personal decisions' (Mesarić et al, 2017:1469). They are not merely focused on the short-term benefits but are interested in the long-term financial viability of energy consumption through this medium. Whilst this unawareness of long-term viability could be linked to a general lack of information, this specific level of behavioural complexity is relatively understudied within SGT literature. Admittedly, certain studies have discovered related costs as key barriers to SGT adoption. However, these generally relate to start-up costs such as installation and consumer sensibility to tariff changes (Mah et al, 2012:213). Furthermore, Toft et al (2014:393) describe how previous literature claims 'short-term financial motives' are a key determining factor in consumer acceptance of SGT. Therefore, it could be argued that these qualitative findings go beyond current literature by presenting the importance of long-term financial viability for many consumers.

4.4. RQ3: To what extent do residents' views of smart-grid technology implementation on the Isles of Scilly present differences or associations between specific population groups?

Drawing upon aim 2, the analysis of RQ3 seeks to examine whether there are any statistically significant differences or relationships between population groups. Using select moderators from the aUTAUT2 to define population groups, this section takes the form of a statistical report. An appropriate null hypotheses will be either rejected or accepted for each statistical test. For this research the defined significance level (p value) was 0.05 (or 5%). It should briefly be stated that the moderators 'household

population' and 'income' did not present any statistically significant associations or differences within this analysis. This is perhaps due to the limited variation of responses obtained from this category.

4.4.1. Age

As discussed in the literature review, numerous academics (Mills and Schleich, 2012; Anderson et al, 2012; Barnicoat and Danson, 2015) have examined how age can influence the perspectives of consumers in relation to SGT. In this research analysis a Kruskal-Wallis test was used to examine whether there were statistically significant differences between two or more groups of the age variable on a number of ordinal dependent variables. The Kruskal-Wallis test was appropriate due to the assumptions of a one-way ANOVA test being violated. For this test, the hypotheses are shown in Table 4.4.1.

Table 4.4.1: Summary table for hypothesis 1.1

Hypothesis number/ Test number	Null and alternative hypotheses
1.1 (Age)	***H0****: There are no statistically significant differences between age groups on dependant variables* ***H1****: There are statistically significant differences between age groups on dependant variables*

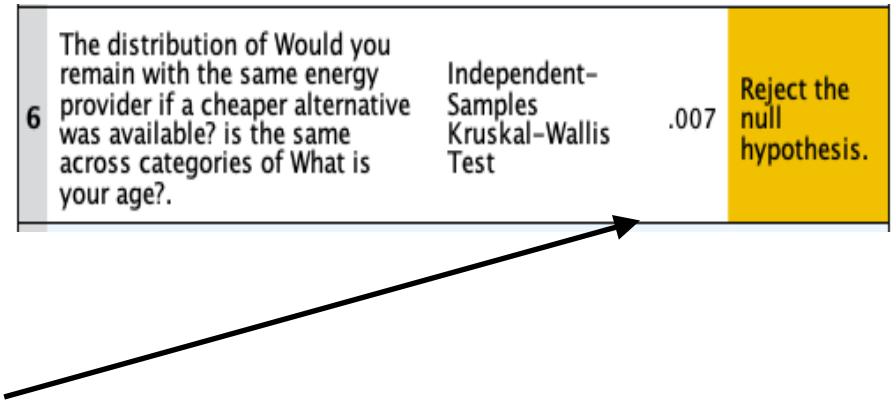
The dependant variables related to questions 5, 6, 7, 8, 10, 11, 16 and 17 (refer to appendix 1 to view questions). Figure 4.1 shows the outcomes of this test. As shown in Figure 4.1, the Kruskal-Wallis test showed that the majority of data sets presented no significance. However, there was statistical significance presented between age groups in relation to question 11, 'would you remain with the same energy provider if a cheaper alternative was available?'. With a strong significance level of 0.007 the null hypotheses was rejected (H0-1.1).

Figure 4.1: Kruskal-Wallis test results of moderator 'age' (question 1). Significant results: question 11/data set 6

Hypothesis Test Summary

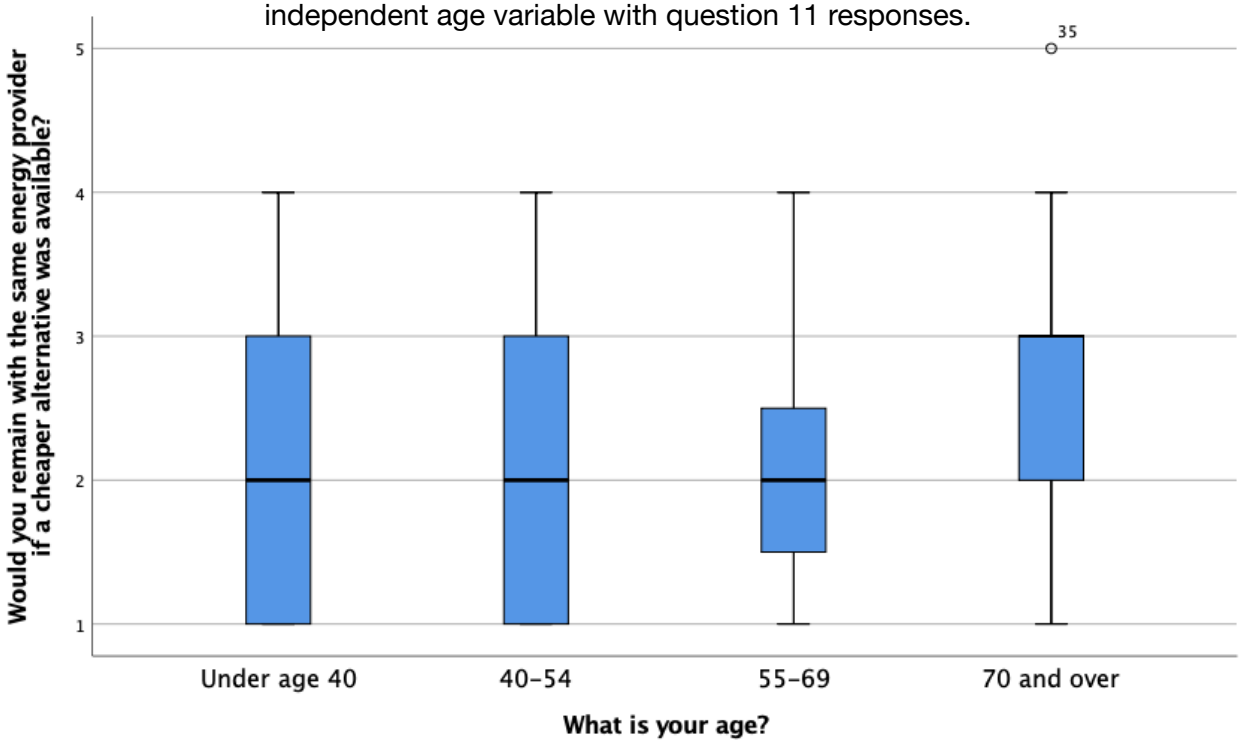
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of How well do you understand the term 'smart-grid'? is the same across categories of What is your age?.	Independent-Samples Kruskal-Wallis Test	.251	Retain the null hypothesis.
2	The distribution of How well do you understand the term 'internet of things'? is the same across categories of What is your age?.	Independent-Samples Kruskal-Wallis Test	.076	Retain the null hypothesis.
3	The distribution of Is a smart meter installed within your household? is the same across categories of What is your age?.	Independent-Samples Kruskal-Wallis Test	.233	Retain the null hypothesis.
4	The distribution of To what extent do you agree with this statement 'I have a good understanding about the implementation of smart-grid technology on the Isles of Scilly'? is the same across categories of What is your age?.	Independent-Samples Kruskal-Wallis Test	.062	Retain the null hypothesis.
5	The distribution of Do you feel the Smart Island's partnership has offered you the appropriate information about smart-grid technology and/or answered questions effectively? is the same across categories of What is your age?.	Independent-Samples Kruskal-Wallis Test	.619	Retain the null hypothesis.
6	The distribution of Would you remain with the same energy provider if a cheaper alternative was available? is the same across categories of What is your age?.	Independent-Samples Kruskal-Wallis Test	.007	Reject the null hypothesis.
7	The distribution of To you, how important is the credibility of an energy supplier or smart meter installer in relation to the implementation of smart-grid components? is the same across categories of What is your age?.	Independent-Samples Kruskal-Wallis Test	.959	Retain the null hypothesis.
8	The distribution of To what extent do you agree with this statement 'I have faith in the organisational bodies attempting to implement smart-grid technology on the Isles of Scilly'? is the same across categories of What is your age?.	Independent-Samples Kruskal-Wallis Test	.308	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.



To identify where this statistical significance lay within question 11 (or data set 6) a box-plot graph was constructed. Figure 4.2 presents the box-plot graph (1-5 on the *y* axis signifies a likert scale from 'definitely not' to 'definitely yes'). The box-plot visually identified noticeable differences between the age

Figure 4.2: Box plot graph comparing the distributions of independent age variable with question 11 responses.



groups. Importantly, it highlighted how the majority of responses from the '70 and over' age group were confined between responses 2-3 whilst the other groups generally spanned across responses 1-3.

To test the statistical validity of these distribution differences a series of Mann-Whitney U tests were applied comparing the '70 and over group' to the others. Additionally, to increase the validity and reliability of statistical significance the 'Bonferroni Correction' was performed (0.05/3=0.0167). It produced a p value=0.0167, the results from the Mann-Whitney U tests had fall under this value to prove statistical significance. The hypotheses of these tests are presented in Table 4.4.2.

Table 4.4.2: Summary table for hypotheses 1.2, 1.3 and 1.4.

Hypothesis number/ Test number	Null and alternative hypotheses
1.2 (Age)	***H0****: There is not a statistically significant difference between whether age groups '70 and over' and 'Under age 40' would remain with the same energy provider if a cheaper alternative was available* ***H1****: There is a statistically significant difference between whether age groups '70 and over' and 'Under age 40' would remain with the same energy provider if a cheaper alternative was available*
1.3 (Age)	***H0****: There is not a statistically significant difference between whether age groups '70 and over' and '40-54' would remain with the same energy provider if a cheaper alternative was available* ***H1****: There is a statistically significant difference between whether age groups '70 and over' and '40-54' would remain with the same energy provider if a cheaper alternative was available*
1.4 (Age)	***H0****: There is not a statistically significant difference between whether age groups '70 and over' and '55-69' would remain with the same energy provider if a cheaper alternative was available* ***H1****: There is a statistically significant difference between whether age groups '70 and over' and '55-69' would remain with the same energy provider if a cheaper alternative was available*

Table 4.4.3 shows the results of the Mann-Whitney U tests. These tests identified statistically significant differences for tests 1.3 ($U=169;p<0.0167$) and 1.4 ($U=115;p<0.0167$), with p values of 0.002 the associated null hypotheses could be rejected (H0-1.3;H0-1.4). Additionally, test 1.2 did show a trend towards significance however did not fall under the Bonferroni correction so the null hypothesis was accepted (H0-1.2).

Table 4.4.3: Summary table of the results from tests 1.2, 1.3 and 1.4.

Age group compared with '70 and over'	Mann-Whitney U statistic	P value	Decision
Under age 40	115.5	0.047	Accept null hypothesis
40-54	169	0.002	Reject null hypothesis
55-69	115	0.002	Reject null hypothesis

In terms of analysis, these results suggest a number of differences between population groups' views on smart-grid implementation and energy developments as a whole on the IOS. The results from Q11 support on some levels how consumers present 'habitual' tendencies (Maréchal, 2010) and are not economically rational. Critically, these results also show how tendencies vary between population groups and reaffirm how differences in age can show subtly diverging energy views (Mills and Schleich, 2012; Anderson et al, 2012). Furthermore, Ellabban and Abu-Rub note how behavioural practices concerning energy change are either 'habitual' or 'one-shot' and 'behaviours towards…whether to engage in a SG project and/or to buy smart appliances, are one-shot behaviour' (2016:1293) . This presents a potential social barrier to the adoption of SGT on the IOS as the results indicate elderly people, who form a large proportion of the regional population, are more habitual than the rest of the population. From this it could be interpreted that elderly people are less likely to engage in one-shot behaviour. This is an issue 'as the successful use of smart technologies for demand response energy gains depends on… people required to move their energy use by changing their routines and habits' (Barnicoat and Danson, 2015:110) or move away from habitual consumption tendencies.

Perhaps the key findings in relation to age demographics, where the various associations between age groups and residents' reasons for not installing SGT. To test the association between age groups and responses from question 15, a Fisher's exact test was performed with the Monte Carlo simulation. A Fisher's exact test was required as the assumptions of a Chi-squared test were violated, namely over 20% of the expected cell count were less than 5. Additionally, a Monte Carlo permutation provided a significance

statistic of greater reliability as the simulation ran the association results against a set of random variables numerous times. Figure 4.3 shows the test results from the Fisher's exact test (refer to appendix 3 for relevant cross-tabulation). The hypotheses are presented in Table 4.4.4.

Table 4.4.4: Summary table for hypothesis 1.5

Hypothesis number/ Test number	Null and alternative hypotheses
1.5 (Age)	***H0****: There is no statistically significant association between age groups and reasons for not installing SGT* ***H1****: There is a statistically significant association between age groups and reasons for not installing SGT*

Figure 4.3: SPSS Screenshot of test 1.5 results.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Monte Carlo Sig. (2-sided)			Monte Carlo Sig. (1-sided)		
				Significance	99% Confidence Interval Lower Bound	99% Confidence Interval Upper Bound	Significance	99% Confidence Interval Lower Bound	99% Confidence Interval Upper Bound
Pearson Chi-Square	66.495[a]	18	.000	.000[b]	.000	.000			
Likelihood Ratio	67.130	18	.000	.000[b]	.000	.000			
Fisher's Exact Test	54.261			.000[b]	.000	.000			
Linear-by-Linear Association	13.609[c]	1	.000	.000[b]	.000	.001	.000[b]	.000	.000
N of Valid Cases	103								

a. 24 cells (85.7%) have expected count less than 5. The minimum expected count is 1.57.

b. Based on 10000 sampled tables with starting seed 1993510611.

c. The standardized statistic is -3.689.

The Fisher's exact test produced a statistic under 0.05 (p=0.000) proving there is an extremely strong association between age groups and their main reasons for not installing SGT. Essentially, this result shows certain age groups on the IOS identify with specific barriers. To evaluate which barriers these were specifically, further Fisher's exact tests were conducted. Table 4.4.5 shows the hypotheses of these tests and summarises the results.

Table 4.4.5: Summary table for hypotheses/ tests of 1.6

Hypothesis number/ Test number	Null and alternative hypotheses	Fisher's exact test statistic/ significance level	Decision
1.6.1 (Age)	***H0**: There is no statistically significant association between age groups and 'confusing technology'* ***H1**: There is a statistically significant association between age groups and 'confusing technology'*	*0.000*	*Reject null hypothesis*
1.6.2 (Age)	***H0**: There is no statistically significant association between age groups and 'satisfied with current provider or energy setup'* ***H1**: There is a statistically significant association between age groups and 'satisfied with current provider or energy setup'*	*0.032*	*Reject null hypothesis*
1.6.3 (Age)	***H0**: There is no statistically significant association between age groups and 'unclear about ownership, compliance rules or privacy regulations'* ***H1**: There is a statistically significant association between age groups and 'unclear about ownership, compliance rules or privacy regulations'*	*0.029*	*Reject null hypothesis*
1.6.4 (Age)	***H0**: There is no statistically significant association between age groups and 'a general lack of information provided by the installer'* ***H1**: There is a statistically significant association between age groups and 'a general lack of information provided by the installer'*	*0.299*	*Accept null hypothesis*
1.6.5 (Age)	***H0**: There is no statistically significant association between age groups and 'the cost of the installation process'* ***H1**: There is a statistically significant association between age groups and 'the cost of the installation process'*	*0.233*	*Accept null hypothesis*
1.6.6 (Age)	***H0**: There is no statistically significant association between age groups and 'I'm not sure/ unknown'* ***H1**: There is a statistically significant association between age groups and 'I'm not sure/ unknown'*	*0.143*	*Accept null hypothesis*
1.6.7 (Age)	***H0**: There is no statistically significant association between age groups and 'other'* ***H1**: There is a statistically significant association between age groups and 'other'*	*0.826*	*Accept null hypothesis*

Table 4.4.5 identifies how the Fisher's exact test statistics of 1.6.1, 1.6.2 and 1.6.3 show statistically significant associations between age groups and the social barriers relating to: confusing technology (p=0.000), consumers' satisfaction with current energy setups (p=0.032) and issues surrounding ownership, compliance and privacy (p=0.029). Therefore, the null hypotheses of these tests can be rejected. Test 1.6.1, which related to 'confusing technology', presented and extremely strong relationship.

Consumers' perception of SGTs and automation technologies as confusing has been recognised as a key social barrier by various academics (Holroyd et al, 2010; Hargreaves et al, 2010). For example, Hargreaves et al (2010:6118) identify how consumers have issues surrounding the composition of UI's (user interfaces) on smart devices and the poorly refined hardware. This was a feature identified by one of the interviewees:

> ***Paul:*** *'Didn't click for me, I don't use iPads and what have you so was a bit alien as it was all touchscreen.'*

Coincidently Paul is age 71, this aligns with the quantitative findings and supports a number of studies that conclude the elderly specifically have perceptions of new technologies as confusing or complicated (Eastman and Iyer, 2004; Marquie et al, 2002). Furthermore, the strong association would suggest how the perception of 'confusing technology' as a primary barrier is related to an increase in age. This may be true and links back to the 'habitual' nature of consumers (Maréchal, 2010). In a study by Balta-Ozkan et al they found 'young people were seen to live for technology' (2013:370), it could therefore be presumed that they would be more interested in new technological developments. However, it could also be argued that this association is merely a generational phenomena. For example, this association proposes that as younger generations become older they increasingly view smart infrastructure as 'confusing technology'. Yet, it could be argued that the current youth will show more relatability to new technologies in the future considering the various technological advancements they have already experienced. Perhaps this relationship is just the result of a 'transitional issue' (Blaschke et al, 2009:646), as most older adults left education before ICT was on the curriculum (Irizzary et al, 2002). Fundamentally, it is inconclusive about the continuation of this association however it is currently very strong and could be a detrimental social barrier to the adoption of SGT on the IOS considering the large elderly population.

4.4.2. Experience

One aspect of this dissertation research aimed to examine whether there were any statistically significant differences or associations between population groups, defined by levels of experience, and their views on SGT. For this research 'experience' was interpreted as the amount of times a participant had been in contact with a representative, or attended forum/meeting, associated with SGT projects on the IOS. This interpretation was necessary due to the small amount of residents who have had hands on experience with SGTs to date.

In exactly the same format as the 'age' moderator, a Kruskal-Wallis test was. The test highlighted that a number of data sets (relating to questions 5, 6, 8, and 10). Due to the significant results, the null hypotheses for this test could be rejected (refer to appendix 4 for the hypotheses table). Figure 4.4. shows the significant results for test 2.1.

Figure 4.4: Kruskal-Wallis test results of moderator 'experience' (question 9). Significant results: questions 5, 6, 8, and 10/data sets 1, 2, 3, and 4.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of How well do you understand the term 'smart-grid'? is the same across categories of How many times have you attended a panel, meeting, or forum and/or been in contact with any representative about the Smart Islands project on the Isles of Scilly?.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
2	The distribution of How well do you understand the term 'internet of things'? is the same across categories of How many times have you attended a panel, meeting, or forum and/or been in contact with any representative about the Smart Islands project on the Isles of Scilly?.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
3	The distribution of To what extent do you agree with this statement 'I have a good understanding about the implementation of smart-grid technology on the Isles of Scilly'? is the same across categories of How many times have you attended a panel, meeting, or forum and/or been in contact with any representative about the Smart Islands project on the Isles of Scilly?.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
4	The distribution of Do you feel the Smart Island's partnership has offered you the appropriate information about smart-grid technology and/or answered questions effectively? is the same across categories of How many times have you attended a panel, meeting, or forum and/or been in contact with any representative about the Smart Islands project on the Isles of Scilly?.	Independent-Samples Kruskal-Wallis Test	.001	Reject the null hypothesis.

Following test 2.1, relevant box-plot graphs and Mann-Whitney U tests were conducted and showed a number of significant differences between population groups that had differing levels of contact/experience (Table 4.5 provides a large summary of these test results). As a result the null hypotheses of these tests could be rejected (refer to appendix 5 for hypotheses table). This process was exactly the same as with the age moderator however the Bonferroni correction was different due to less pairwise comparisons, as such the p values only had to fall under 0.025.

Table 4.5: Summary table of the results from tests 2.2, 2.3, 2.4 and 2.5.

Hypotheses number/Test number	Mann-Whitney U statistic	P value	Decision
2.2.1	86	0.004	Reject null hypothesis
2.2.2	162	0.000	Reject null hypothesis
2.3.1	69	0.001	Reject null hypothesis
2.3.2	218	0.000	Reject null hypothesis
2.4.1	112	0.043	Reject null hypothesis
2.4.2	236	0.000	Reject null hypothesis
2.5.1	162.5	0.625	Accept null hypothesis
2.5.2	440.5	0.012	Reject null hypothesis

Almost every Mann-Whitney U test presented statistically significant differences between experience groups. To analyse the Mann-Whitney U results individually would arguably provide a more in-depth analysis, however these results are analogous as they all relate to participants' levels of understanding about SGT implementation on the IOS.

The main trend that these differences suggest is that participant's with a higher contact frequency, or experience level, have a greater level of understanding in relation to smart-grid concepts and implementation on the IOS. These findings suggest the more contact participants have with smart-grid-related organisational bodies, the better their understanding of SGT becomes. Higher levels of understanding have been distinguished as key

enablers for the adoption of SGT as they improve 'the perceptions of ease of use and usefulness' (Park et al, 2014:217). A key pattern in this literature is criticism of organisational bodies about their openness of information, particularly in relation to ownership and privacy issues (McDaniel and McLaughlin, 2009). However, these findings highlight the effectiveness of organisational contact with participants on the IOS in increasing the understanding among residents. As such, it could be argued that the barrier is not the clarity or holding-back of information but rather the accessibility and availability of this information. Undoubtedly, the role organisational bodies have to play in making information easily accessible is paramount and the literature is right to criticise many organisations for their poor communication with consumers. However this is simply not the case on the IOS, the 'Smart Islands' partners have held numerous forums on all the inhabited islands and produced monthly newsletters to update residents on the project. As such, it could be interpreted that the role of the consumer in accessing information is currently understated within literature and policy. The qualitative data also support this conclusion. A number of interviewees, such as Selena (a St Mary's resident, age 44 without SGT installed), identified how their lack of understanding was not the fault of the organisational bodies but their own:

Selena: *'If I am to be honest I would actually say they couldn't of done much more but I just have been naughty in not taking much notice. I've been really slack.'*

There are few studies surrounding this topic, perhaps this is because questions around how to mobilise communities to become more engaged with SGT are hard to answer due to the 'complexity associated with negotiating, engaging and motivating pro-environmental consumer behaviours' (Gangale et al, 2013:622). As Brodie et al (2013) highlight, consumer engagement is a psychological and emotional process making it hard to evaluate. Consequentially, incentives for consumers to increase understanding are difficult to form considering the personal nature of environmental behaviours.

4.5. RQ4: To what extent are attitudes towards smart-grid technology adoption effected by geography and location on the Isles of Scilly?

Stemming from the literature review of this dissertation it was identified that some academics had drawn upon concepts of place attachment (Wolsink, 2012; Devine-Wright, 2009). Furthermore, other academics have also highlighted the role of location, and cultural heritage (Alkon, 2004), to justify certain energy consumption behaviours and perspectives. Drawing upon aim 3, this section of the analysis examines how spatially defined population groups on the IOS (residents on St Mary's or off-islands) present perspective associations in relation to specific motivators for the adoption of SGT.

After conducting a Kruskal-Wallis test, no statistically significant differences were found. However, there was one noticeable association. After conducting a Fisher's exact test between participants' 'Island of residency' and their main reason for installing a smart-grid component (refer to appendix 1 - question 14) an extremely strong statistically significant association was shown (p=0.000). Table 4.6 and Figure 4.5 show the hypotheses and results of this test (refer to appendix 6 for cross tabulation).

Table 4.6: Summary table for hypothesis 3.1

Hypothesis number/ Test number	Null and alternative hypotheses
3.1 (Island of Residency)	***H0****: There is no statistically significant association between 'island of residency' and reasons for installing SGT* ***H1****: There is a statistically significant association between 'island of residency' and reasons for installing SGT*

Figure 4.5: SPSS screenshot of test 3.1 results

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Monte Carlo Sig. (2-sided)			Monte Carlo Sig. (1-sided)		
				Significance	99% Confidence Interval		Significance	99% Confidence Interval	
					Lower Bound	Upper Bound		Lower Bound	Upper Bound
Pearson Chi-Square	42.372[a]	4	.000	.000[b]	.000	.000			
Likelihood Ratio	36.463	4	.000	.000[b]	.000	.000			
Fisher's Exact Test	32.738			.000[b]	.000	.000			
Linear-by-Linear Association	1.368[c]	1	.242	.271[b]	.259	.282	.140[b]	.131	.149
N of Valid Cases	103								

The null hypothesis (H0-3.1) of this test could be rejected due to the strong significance level. To identify which specific motivations locational populations were associated with a series of Fisher's exact tests and, where appropriate, Chi-squared tests were performed. Table 4.7 summarises the results of these tests. Chi-squared tests were appropriate at points as certain data sets had less than 20% of expected counts below 5. Additionally, the tables were 2x2 therefore the Monte-Carlo permutations were not required in this case.

Table 4.7: Summary table for test 3.2 (hypotheses and association results)

Hypothesis number/ Test number	Null and alternative hypotheses	Fisher's exact test statistic/ Chi-squared significance level	Decision
3.2.1 (Island of Residency)	***H0**: There is no statistically significant association between 'island of residency' and 'reduce energy costs'* ***H1**: There is a statistically significant association between 'island of residency' and 'reduce energy costs'*	*0.002*	*Reject null hypothesis*
3.2.2 (Island of Residency)	***H0**: There is no statistically significant association between 'island of residency' and 'reduce island's emissions'* ***H1**: There is a statistically significant association between 'island of residency' and 'reduce island's emissions'*	*0.000*	*Reject null hypothesis*
3.2.3 (Island of Residency)	***H0**: There is no statistically significant association between 'island of residency' and 'to increase control of household usage'* ***H1**: There is a statistically significant association between 'island of residency' and 'to increase control of household usage'*	*0.053*	*Accept null hypothesis*
3.2.4 (Island of Residency)	***H0**: There is no statistically significant association between 'island of residency' and 'recommended it by a friend or council member'* ***H1**: There is a statistically significant association between 'island of residency' and 'recommended it by a friend or council member'*	*0.588*	*Accept null hypothesis*
3.2.5 (Island of Residency)	***H0**: There is no statistically significant association between 'island of residency' and 'other'* ***H1**: There is a statistically significant association between 'island of residency' and 'other'*	*1.000*	*Accept null hypothesis*

Table 4.7 identifies how tests 3.2.1 and 3.2.2 resulted in statistically significant associations (p=0.002; p=0.000), the null hypotheses of these tests can be rejected (H0-3.2.1;H0-3.2.2). From further analysis of the cross tabulations for these tests (refer to appendices 7 and 8 for cross tabulations) it shows how these associations are caused. 82% of residents from off-islands chose their main reason for installing SGT would be to 'reduce island's emissions' compared to only 10.5% of from St Mary's. Conversely, 53% of residents from St Mary's identified their main motivator would be to 'reduce energy costs' compared to just 11.8% who chose this option from off-islands.

There are a number of reasons that may suggest why these particular associations occurred. From the interview and questionnaire responses it was clear that for the most part IOS residents from all islands show an appreciation of the physical environment. However, this appreciation is arguably more noticeable 'on the off-islands, [where] a higher degree of isolation produces an increased necessity for self-reliance' (Petzold, 2018:112). This self-reliance comes in various environmental forms such as depending greatly on local produce, foraging for certain foods, and understanding the local tides and weather. As such, due to the greater reliance on environmental factors, it could be suggested off-island residents manifest a greater level of place attachment.

Numerous academics have identified how concepts such as place attachment can influence energy perspectives (Wolsink, 2012; Twigger-Ross and Uzzell, 1996), yet Devine-Wright states 'whether the project will directly enhance the local community… will predominantly influence public responses' (2009:434). By this reasoning, in the case of off-island responses, the main motivation to reduce the island's emissions makes sense. By reducing emissions residents would essentially be ensuring the local environment remains sustainable along with the continued availability of important resources. However, it could be argued these associations are the result of more simple socio-economic circumstances. Further analysis of the annual income results shows how 82.3% of the 'off-island' responses earn over £21,000 annually compared to just 63.9% of 'St Mary's' residents (refer to appendices 8 for cross tabulation). Therefore, it could simply be argued that due to the higher earnings of off-island residents, energy costs are less of an

issue as they are for residents on ‘St Mary’s. Fundamentally off-island residents’ socio-economic circumstances, combined with their place attachment and cultural norms, may explain why to ‘reduce island’s emissions’ is their main motive for the adoption of SGT.

5

Conclusions

5.1. Introduction to Chapter 5

This chapter will answer the research questions which were stated previously in this dissertation and analysed in chapter 4. This section also aims to identify future avenues for smart-grid research and the limitations of this project.

5.2. Reflecting on the Research Questions

RQ1 looked to identify the main motivations for the adoption of SGT on the IOS. The results showed how a reduction in energy costs was the most popular motivation response. This research supports the assumption that financial savings are the primary enabler for the adoption of SGTs (Toft et al, 2014:393; Paetz, A., et al 2012:27) and suggests constructions of the rational economic consumer within SG imaginaries are not entirely misplaced (Ballo, 2015; Levenda et al; 2015; Silvast et al, 2018). However, the majority of the responses were distributed among options related to social and environmental influences. In RQ2 analysis prevailing barriers were socially orientated. However, qualitative data also identified how consumers were concerned with long-term financial issues. In answering RQ1 and RQ2, financial issues and incentives clearly remain key factors within many consumers' decision-making. However, this research has found social, cultural, and environmental factors to be of greater influence for the majority of IOS residents. As such, this dissertation supports academics (Wolsink, 2012; Balta-Ozkan et al, 2013) who emphasise the importance of social factors within SGTs. However, it does not completely abandon constructions of rational economic actors within smart-grid imaginaries.

RQ3 asked whether there were perspective differences or associations between population groups. Elderly age groups were less willing to change energy services purely on the prospect of financial savings. This suggests the elderly are more habitual than younger age groups (Maréchal, 2010). Furthermore, there was a strong association between elderly age groups not adopting SGT due to perceptions of it as confusing. This aligns with the work of Eastman and Iyer (2004), and Marquie et al (2002), who have highlighted the elderly's unwillingness to adopt new technologies. Associations were also identified between population groups with differing levels of experience. Those with a higher contact frequency had a greater understanding of SGT. On some level this supports literature encouraging organisational bodies to provide more accessible information to consumers (Guo et al, 2015) to increase consumer understanding and consequently adoption. However, on the IOS the issue was not the availability of information from organisational bodies, but the mobilisation of consumers to get in contact.

RQ4 considered the role of geography in SGT adoption. A clear association was evident as 82% of off-island residents chose a reduction in emissions as their main incentive for installing SGT compared to only 10.5% of St Mary's residents. In the analysis section these results were linked to place attachment (Devine-Wright, 2009; Twigger-Ross and Uzzell, 1996), and cultural norms and traditions (Alkon, 2004), which relate to the off-islanders high dependance on natural resources. Furthermore, in this situation location influenced specific socio-economic circumstances with off-island residents earning more than St Mary's residents.

5.3. Limitations, Future Research Avenues and Policy Directions

Whilst this study has provided an effective snapshot of consumer perceptions and differences, there are a number of limitations to this research. Importantly, there were a number of time, cost and accessibility restrictions given the isolation of the IOS and the researcher being based in Cardiff. Furthermore, methodologically, the case study approach was appropriate due to the particularly rare set of circumstances the IOS bestowed. However, this

study should not be generalised in relation to other rural communities within the UK.

There are a number of future avenues researchers, organisations and policy-makers should address. Crucially, the social factors preventing and enabling the implementation of SGT should be given far more attention. Research relating to the economic side of consumer decision-making should not be diminished, financial aspects still remain important for many, however this dissertation suggests consumers are more effected by social influences. Additionally, efforts should be made to adjust the perceptions of elderly populations. They have a major role to play in the adoption of SGT in the UK considering their large population size. Policy efforts should be made to educate this age group by increasing their ICT knowledge and perceived ease of use. Furthermore, in a wider sense, mobilising potential consumers to engage with informational bodies will increase their understanding and perhaps adoption. Future research should discuss how this mobilisation can occur and ask to what extent can organisational bodies be held responsible for informing citizens. Finally, the role of location and culture in constructing or necessitating specific socio-economic circumstances and perspectives should be examined in greater detail. The advertisement of specific SG benefits may resonate more with locationally different populations.

Bibliography

Abrahamse, W., Steg, L., Vlek, C. and Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology.* Volume 25(3). pp. 273-291.

Ajzen, I. (1991). The Theory of Planned Behaviour. *Organisational Behaviour and Human Decision Processes.* Volume 50. 179-211.

Alkon, A. (2004). Place, stories, and consequences - heritage narratives and the control of erosion on Lake County, California, vineyard. *Organization and Environment.* Volume 17. pp. 145-169.

Ameli, N. and Brandt, N. (2014). Determinants of households' investment in energy efficiency and renewables. *OECD economics department working papers.* Paris: Organisation for Economic Co-operation and Development.

Anderson, W., White, V. and Finney, A. (2012). Coping with low incomes and cold homes. *Energy Policy.* Volume 49. pp. 40-52.

Badham, R., Clegg, C. and Wall, T. (2000). Socio-technical theory. In: Karwowski, W. (eds). *Handbook of Ergonomics*. New York: John Wiley.

Bagozzi, R. (2007). The legacy of the technology acceptance model and a proposal for a paradigm shift. *Journal of the Association for Information Systems.*Volume 8(4). pp. 244-254.

Ballo, I. (2015). Imagining energy futures: Sociotechnical imaginaries of the future Smart Grid in Norway. *Energy Research & Social Science.* Volume 9. pp. 13.

Balta-Ozkan, N., Davidson, R., Bicket, M. and Whitmarsh, L. (2013). Social barriers to the adoption of smart homes. *Energy Policy.* Volume 63. pp. 364.

Balta-Ozkan, N., Davidson, R., Bicket, M. and Whitmarsh, L. (2013). Social barriers to the adoption of smart homes. *Energy Policy.* Volume 63. pp. 363-374.

Balta-Ozkan, N., Davidson, R., Bicket, M. and Whitmarsh, L. (2013). Social barriers to the adoption of smart homes. *Energy Policy.* Volume 63. pp. 369.

Balta-Ozkan, N., Davidson, R., Bicket, M. and Whitmarsh, L. (2013). Social barriers to the adoption of smart homes. *Energy Policy.* Volume 63. pp. 370.

Balta-Ozkan, N., Davidson, R., Bicket, M. and Whitmarsh, L. (2013). Social barriers to the adoption of smart homes. *Energy Policy.* Volume 63. pp. 372.

Barnicoat, G. and Danson, M. (2015). The ageing population and smart metering: A field study of householders' attitudes and behaviours towards energy use in Scotland. *Energy Research and Social Science.* Volume 9. pp. 110.

Barnicoat, G. and Danson, M. (2015). The ageing population and smart metering: A field study of householders' attitudes and behaviours towards energy use in Scotland. *Energy Research and Social Science.* Volume 9. pp. 114.

Baxter, G. and Sommerville, I. (2011). Socio-technical systems: From design methods to systems engineering. *Interacting with Computers.* Volume 23. pp. 5.

Blaschke, C., Freddolino, P. and Mullen, E. (2009). Ageing and Technology: A Review of the Research Literature. *British Journal of Social Work.* Volume 39(4). pp. 646.

Blumsack, S. and Fernandez, A. (2012). Ready or not, here comes the smart grid! *Energy.* Volume 37. pp. 61.

Bridge, G., Bouzarovski, S., Bradshaw, M. and Eyre, N. (2013). Geographies of energy transition: Space, place and the low-carbon economy. *Energy Policy.* Volume 53. pp. 331-340.

Brodie, R., Ilic, A., Juric, B. and Hollebeek, L. (2013). Consumer engagement in a virtual brand community: An exploratory analysis. *Journal of Business Research.* Volume 66. pp. 105-114.

Bulkeley, H., Castán Broto, V., Hodson, M. and Marvin, S. (2010). *Cities and low carbon transitions*. London: Routledge.

Bulkeley, H., Castán Broto, V. and Maassen, A. (2013). Low-carbon Transitions and the Reconfiguration of Urban Infrastructure. *Urban Studies.* Volume 51(7). pp. 1471-1486.

Calvert, K. (2015). From 'energy geography' to 'energy geographies'. *Progress in Human Geography.* Volume 40(1). pp. 105-125.

Care and Support in Cornwall. (2018). *Reducing Fuel Poverty and Improving Winter Warmth*. [online]. Available at: https://www.supportincornwall.org.uk/kb5/cornwall/directory/service.page?id=eYx4F6BY3HA [Accessed 14th Nov. 2018].

Carson, D., Gilmore, A., Perry, C. and Gronhaug, K. (2001). *Qualitative Marketing Research*. London: Sage Publications.

Check, J. and Schutt, R. (2012). Survey research. In: Check, J. and Schutt, R. eds. *Research methods in education*. California: Sage Publications. pp. 160.

Cherry, C., Hopfe, C., MacGillvray, B. and Pidgeon, N. (2017). Homes as machines: Exploring expert and public imaginaries of low carbon housing futures in the United Kingdom. *Energy Research and Social Science.* Volume 23. pp. 40.

Clancy, J. and Roehr, U. (2003). Gender and energy: is there a Northern perspective?. *Energy for Sustainable Development.* Volume 7(3). pp. 16-22.

Cloke, P. (1977). An index of rurality for England and Wales. *Regional Studies.* Volume 11. pp. 35.

Connor, P., Axon, C., Xenias, D. and Balta-Ozkan, N. (2018). Sources of risk and uncertainty in UK smart grid deployment: An expert stakeholder analysis. *Energy.* Volume 161. pp. 1-9.

Cornwall Guide. (2018). *Isles of Scilly*. [online]. Available at: https://www.cornwalls.co.uk/Isles-of-Scilly [Accessed 13th Nov. 2018].

Dalen, H. and Halvorsen, B. (2011). *Gender differences in environmental related behaviour*. Norway: Statistics Norway. pp. 7.

Davidson, D. and Freudenberg, W. (1996). Gender and Environmental Risk Concerns: A Review and Analysis of Available Research. *Environment and Behaviour.* Volume 28(3). pp. 302-339.

Davis, F., Bagozzi, R. and Warshaw, P. (1989). User Acceptance of Computer: A Comparison of Two Theoretical Models. *Management Science.* Volume 35(8). pp. 985.

Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly.* Volume 13(3). pp. 319-340.

DEFRA. (2014). *Official Statistics: Rural population 2014/15*. [online] GOV.UK. Available at: https://www.gov.uk/government/publications/rural-population-and-migration/rural-population-201415 [Accessed 16 Oct. 2018].

Denzin, N. (1970). *The Research Act: A theoretical introduction to sociological methods.* Chicago: Aldine.

Devine-Wright, P. (2009). Rethinking NIMBYism: The Role of Place Attachment and Place Identity in Explaining Place-protective Action. *Journal of Community & Applied Social Psychology*. Volume 19. pp. 426-441.

Devine-Wright, P. (2009). Rethinking NIMBYism: The Role of Place Attachment and Place Identity in Explaining Place-protective Action. *Journal of Community & Applied Social Psychology*. Volume 19. pp. 434.

DeWalt, K. and DeWalt, B. (2011). *Participant Observation: A Guide for Fieldworkers*. 2nd Ed. Plymouth: AltaMira Press. pp. 1.

Dugan, E. (2008). *The Isles of Scilly, where Britain's poorest people live*. [online] The Independent. Available at: https://www.independent.co.uk/news/uk/this-britain/the-isles-of-scilly-where-britains-poorest-people-live-782992.html [Accessed 2nd Dec. 2018].

Eastman, J. and Iyer, R. (2004). The elderly's uses and attitudes towards the Internet. *Journal of Consumer Marketing*. Volume 21(3). pp. 208-220.

Ellabban, O. and Abu-Rub, H. (2016). Smart grid customers' acceptance and engagement: An overview. *Renewable and Sustainable Energy Reviews.* Volume 65. pp. 1293.

Evans, J. and Mathur, A. (2005). The value of online surveys. *Internet Research.* Volume 15(2). pp. 197.

Frantál, B. and Martinát, S. (2013). New Challenges, Conflicts and Opportunities for Rural Spaces. In: Frantál, B. and Martinát, S. (eds). *New Rural Spaces: Towards Renewable Energies, Multifunctional Farming, and Sustainable Tourism*. Brno: Institute of Geonics. pp. 10.

FREE. (2011). Future of Rural Energy (Free) England: Year 1 Report. [online]. Available at: http://www.cumbriaaction.org.uk/Portals/0/Other%20Publications/Calor%20FREE%20Year%201%20England%20Report.pdf [Accessed 20 Oct. 2018]. pp. 6.

Gangale, F., Mengolini, A. and Onyeji, I. (2013). Consumer engagement: An insight from smart grid projects in Europe. *Energy Policy.* Volume 60. pp. 622.

Gangale, F., Mengolini, A. and Onyeji, I. (2013). Consumer engagement: An insight from smart grid projects in Europe. *Energy Policy.* Volume 60. pp. 626.

Geels, F. (2012). A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. *Journal of Transport Geography.* Volume 24. pp. 471-482.

Geels, F. (2014). Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. *Theory, Culture & Society.* Volume 31(5). pp. 21-40.

Geertz, C. (1995). *After the Fact: Two Countries, Four Decades, One Anthropologist*. Massachusetts: Harvard University Press.

Golubchikov, O. and Badyina, A. (2012). *Sustainable Housing for Sustainable Cities: A Policy Framework for Developing Countries*. Nairobi: UN-Habitat.

Goulden, M., Bedwell, B., Rennick-Egglestone, S., Rodden, T. and Spence, A. (2014). Smart grids, smart users? The role of the user in demand side management. *Energy Research and Social Science.* Volume 2. pp. 21-29.

Guo, C., Bond, C. and Narayanan, A. (2015). *The Adoption of New Smart-Grid Technologies: Incentives, Outcomes, and Opportunities*. California: The RAND Corporation. pp. 36

Hardy, J. (2012). *Policy, Regulatory and Social Aspects of of Smart-Grid Application, 2012*. UKERC Workshop Report.

Hargreaves, T., Nye, M. and Burgess, J. (2010). Making energy visible: A qualitative field study of how householders interact with feedback from smart energy monitors. *Energy Policy.* Volume 30.

Hargreaves, T., Nye, M. and Burgess, J. (2010). Making energy visible: A qualitative field study of how householders interact with feedback from smart energy monitors. *Energy Policy.* Volume 30. pp. 6118.

Hitachi Europe Ltd. (2016). *Energy Infrastructure Plan for the Isles of Scilly*. [online]. Available at: https://static1.squarespace.com/static/554637f4e4b08ca26f7cb20f/t/58aee1e0d1758ef40ffae688/1487856123064/Isles+of+Scilly+Energy+Infrastructure+Plan+2016+-+Smart+Islands.pdf [Accessed 15th Nov. 2018]. pp. 38.

Hodges, N., Roberts, S., Smith, K., Bridgeman, T., Banks, N. and Asher, M. (2016). *Smart prepayment & fuel poverty: A report for eaga charitable trust*. Bristol: Centre for Sustainable Energy. pp. 21.

Hodson, M. and Marvin, S. (2012). Mediating Low-Carbon Urban Transitions? Forms of Organization, Knowledge and Action. *European Planning Studies.* Volume 20(3). pp. 421-439.

Holden, R. and Karsh, B. (2010). The Technology Acceptance Model: Its past and its future in health care. *Journal of Biomedical Informatics.* Volume 43(1). pp. 159.

Holroyd, P., Watten, P. and Newbury, P. (2010). Why Is My Home Not Smart?. In: Lee, Y., Bien, Z., Mokhtari, M., Kim, J., Park, M., Kim, J., Lee, H. and Khalil, I. eds. *Aging Friendly Technology for Health and Independence*. Berlin: Springer.

IET. (2013). *What is a Smart-Grid?*. [online]. Available at: https://www.theiet.org/factfiles/energy/smart-grids-page.cfm [Accessed 4th December. 2018]. pp. 3.

IPCC. (2007). *Climate Change 2007*. Volume 4. Cambridge: Cambridge University Press.

IPCC. (2018). *Global Warming of 1.5°C*. [online]. Available at: http://www.ipcc.ch/report/sr15/ [Accessed 18 Oct. 2018].

Irizarry, C., Downing, A. and West, D. (2002). Promoting modern technology and internet access for under-represented older populations. *Journal of Technology in Human Services.* Volume 19(4). pp. 13-30.

Jabłońska, M. (2014). Internet of Things in Smart Grid Deployment. *Rynek Energii*. Volume 2(111). pp. 121.

Jenkins, N., Long, C. and Wu, J. (2015). An Overview of the Smart Grid in Great Britain. *Engineering.* Volume 1(4). pp. 419.

Kappagantu, R. and Arul Daniel, S. (2018). Challenges and issues of smart grid implementation: A case of Indian scenario. *Journal of Electrical Systems and Information Technology*. Volume 5(3). pp. 460.

Lai, P. (2017). The Literature Review of Technology Adoption Models and Theories for the Novelty Technology. *Journal of Information Systems and Technology Management.* Volume 14(1). pp. 22.
Levenda, A., Mahmoudi, D. and Sussman, G. (2015). The Neoliberal Politics of 'Smart': Electricity Consumption, Household Monitoring, and the Enterprise Form. *Canadian Journal of Communication.* Volume 40(4). pp. 615-636.

Lewis-Beck, M., Bryman, A. and Futing Liao, T. (2004). *The SAGE Encyclopedia of Social Science Research Methods: Volume 3*. California: Sage publications. pp. 1142.

Lewis-Beck, M., Bryman, A. and Futing Liao, T. (2004). *The SAGE Encyclopedia of Social Science Research Methods: Volume 3*. California: Sage publications. pp. 1104.

Local Government Association. (2016). *Reports: % of households in fuel poverty in Isles of Scilly*. [online]. Available at: https://lginform.local.gov.uk/

reports/lgastandard?mod-area=E06000053&mod-group=AllRegions_England&mod-metric=2131&mod-type=namedComparisonGroup [Accessed 14th Nov. 2018].

Losi, A., Mancarella, P. and Vicino, A. (2015). *Integration of Demand Response into the Electricity Chain: Challenges, Opportunities and Smart Grid Solutions*. London: ISTE Ltd.

Luque-Ayala, A. (2016). *Geographies of Energy*. [online] Oxford Bibliographies Online Datasets. Available at: http://www.oxfordbibliographies.com/view/document/obo-9780199874002/obo-9780199874002-0132.xml [Accessed 18 Oct. 2018].

Mah, D., Van der Vleuten, J., Hills, P. and Tao, J. (2012). Consumer perceptions of smart grid development: Results of a Hong Kong survey and policy implications. *Energy Policy.* Volume 49. pp. 213.

Mann, C. and Stewart, F. (2000). *Internet Communication and Qualitative Research: A Handbook for Researching Online*. London: Sage.

Maréchal, K. (2010). Not irrational but habitual: The importance of “behavioural lock-in” in energy consumption. *Ecological Economics.* Volume 69(5). pp. 1104-1114.

Marquie, J., Jourdan-Boddaert, L. and Huet, N. (2002). Do older adults underestimate their actual computer knowledge?. *Behaviour and Information Technology.* Volume 21(4). pp. 273-280.

Mathieson, K. (1991). Predicting user intentions: comparing the TAM with the theory of planned behaviour. *Information Systems Research.* Volume 2(3). 173-191.

McDaniel, P. and McLaughlin, S. (2009). Security and Privacy Challenges in the Smart Grid. *IEEE Security & Privacy.* Volume 7(3). pp. 75-77.

McKenzie-Mohr, D. (2000). Promoting sustainable behaviour: an introduction to community-based social marketing. *Journal of Social Issues.* Volume 56(3). pp. 543-554.

Mert, W., Watts, M. and Tritthart, W. (2009). Smart domestic appliances in sustainable energy systems - consumer acceptance and restrictions. In: *Proceedings of the ECEEE 2009 Summer Study*. [online]. Available at: https://www.eceee.org/static/media/uploads/site-2/library/conference_proceedings/eceee_Summer_Studies/2009/Panel_8/8.155/paper.pdf [Accessed 2nd Dec. 2018] pp. 1751-1761.

Mesarić, P., Đukec, D. and Krajcar, S. (2017). Exploring the Potential of Energy Consumers in Smart Grid Using Focus Group Methodology. *Sustainability.* Volume 9(8). pp. 1465.

Mesarić, P., Đukec, D. and Krajcar, S. (2017). Exploring the Potential of Energy Consumers in Smart Grid Using Focus Group Methodology. *Sustainability.* Volume 9(8). pp. 1469.

Mills, B. and Schleich, J. (2012). Residential energy-efficient technology adoption, energy conservation, knowledge, and attitudes: An analysis of European countries. *Energy Policy.* Volume 49. pp. 616-628.

Nyborg, S. and Røpke, I. (2013). Constructing users in the smart grid—insights from the Danish eFlex project. *Energy Efficiency.* Volume 6(4). pp. 665.

Ofgem. (2017). *Upgrading Our Energy System: Smart Systems and Flexibility Plan*. [online]. Available at: https://www.ofgem.gov.uk/system/files/docs/2017/07/upgrading_our_energy_system_-_smart_systems_and_flexibility_plan.pdf [Accessed 20 Oct. 2018]. pp. 5.

ONS. (2017). *Overview of the UK Population: July 2017*. [online]. Available at:https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/articles/overviewoftheukpopulation/july2017 [Accessed 28th Oct. 2018].

Opdenakker, R. (2006). Advantages and disadvantages of four interview techniques in qualitative research. *Forum: Qualitative Social Research*. Volume 7(4). pp. 4.

Oxford Dictionaries. (2018). *Smart-Grid*. [online]. Available at: https://en.oxforddictionaries.com/definition/smart_grid [Accessed 12 Dec. 2018].

Paetz, A., Dütschke, E. and Fichtner, W. (2012). Smart Homes as a Means to Sustainable Energy Consumption: A Study of Consumer Perceptions. *Journal of Consumer Policy*. Volume 35. pp. 37.

Paetz, A., Dütschke, E. and Fichtner, W. (2012). Smart Homes as a Means to Sustainable Energy Consumption: A Study of Consumer Perceptions. *Journal of Consumer Policy*. Volume 35. pp. 27.

Park, C., Kim, H. and Kim, Y. (2014). A study of factors enhancing smart grid consumer engagement. *Energy Policy.* Volume 72. pp. 217.

Paterson, M. (1996). *Global Warming and Global Politics*. New York: Routledge.

Petzold, J. (2018). Social adaptability in ecotones: sea-level rise and climate change adaptation in Flushing and the Isles of Scilly, UK. *Island Studies Journal.* Volume 13. pp. 112.

Ragin, C. (1992). Casing and the Process of Social Inquiry. In: Ragin, C. and Becker, H. eds. *What is a Case? Exploring the Foundations of Social Inquiry*. Cambridge: Cambridge University Press. pp. 225.

Risteska Stojkoska, B. and Trivodaliev, K. (2017). A review of Internet of Things for smart home: Challenges and solutions. *Journal of Cleaner Production*. pp. 1455.

Salkind, N. (2010). *Encyclopedia of Research Design.* California: Sage publications.

Schwartz, S. (1977). Normative Influences on Altruism. *Advances in Experimental Social Psychology.* Volume 10. pp. 221-279.

Scilly.gov. (2018). *Smart Islands.* [online]. Available at: http://www.scilly.gov.uk/business-licensing/smart-islands [Accessed 23rd Oct. 2018].

Secor, A. (2010). Social Surveys, Interviews and Focus Groups. In: Gomez, B. and Jones, J. eds. *Research Methods in Geography: A Critical Introduction*. Oxford: Wiley-Blackwell. pp. 196.

Sharma, G. (2017). Pros and cons of different sampling techniques. *International Journal of Applied Research.* Volume 3(7). pp. 750.

Sherry-Brennan, F. and Pearson, P. (2015). *Spatial governance and energy transitions: The 'problem' of rural electrification in England and Wales*. [online] Realising Transition Pathways Working Paper 2015/2. Available at: http://www.realisingtransitionpathways.org.uk/realisingtransitionpathways/publications/Working_papers_and_reports/RTP_Working_Paper_2015_2_Sherry-Brennan_x_Pearson.pdf [Accessed 19 Oct. 2018].

Shove, E., Pantzar, M. and Watson, M. (2012). *The Dynamics of Social Practice: Everyday Life and How It Changes*. London: SAGE.

Silvast, A., Williams, R., Hyysalo, S., Rommetveit, K. and Raab, C. (2018). Who 'Uses' Smart Grids?: The Evolving Nature of User Representations in Layered Infrastructures. *Sustainability.* Volume 10(10). pp. 3738-3759.

Sintov, N. and Shultz, P. (2015). Unlocking the potential of smart grid technologies with behavioural science. *Frontiers in Psychology.* Volume 6. pp. 2.

Smart Energy GB. (2016). *Smart Future: About the Rollout*. [online]. Available at: https://www.smartenergygb.org/en/smart-future/about-the-rollout [Accessed 19 Oct. 2018].

Smart Islands. (2018). *About*. [online]. Available at: https://smartislands.org/about/ [Accessed 15th Nov. 2018].

Snape, R., Irvine, K. and Rynikiewicz, C. (2011). Understanding energy behaviours and transitions through the lens of a smart grid Agent Based Model. In: *Energy efficiency first: The foundation of a low-carbon society*. [online]. France: ECEEE. Available at: https://dora.dmu.ac.uk/handle/2086/7965 [Accessed 20 Oct. 2018]. pp. 1919-1930.

Sovacool, B., Kivimaa, P., Hielscher, S. and Jenkins, K. (2017). Vulnerability and resistance in the United Kingdom's smart meter transition. *Energy Policy.* Volume 109. pp. 767-781.

Stern, P., Dietz, T., Abel, T., Guagnano, G. and Kalof, L. (1999). A Value-Belief-Norm Theory of Support for Social Movements: The Case of Environmentalism. *Human Ecology Review.* Volume 6(2). pp. 81-97.

Shin, D. (2014). A socio-technical framework for Internet-of-Things design: A human-centered design for the Internet of Things. *Telematics and Informatics.* Volume 31. pp. 519-531.

The Rural Coalition. (2010). *The Rural Challenge: Achieving sustainable rural communities for the 21st century*. London: Town and Country Planning Association. pp. 8.

Toft, M., Schuitema, G. and Thøgersen, J. (2014). Responsible technology acceptance: Model development and application to consumer acceptance of Smart Grid technology. *Applied Energy.* Volume 134. pp. 393

Twigger-Ross, C. and Uzzell, D. (1996). Place and Identity Processes. *Journal of Environmental Psychology.* Volume 16(3). pp. 205-220.

UNFCCC. (2018). *The Paris Agreement*. [online]. Available at: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement [Accessed 12 Sep. 2018].

Urbistat. (2015). Demography: Municipality of Isles of Scilly. [online]. Available at: https://ugeo.urbistat.com/AdminStat/en/uk/demografia/eta/scilly-isles/262/4 [Accessed 21 Oct. 2018].

Van der Ploeg, J.D., Broekhuizen, R., Brunori, G., Sonnino, R., Knickel, K., Tisenkopfs, T. and Oostindie, H. (2008). Towards a New Theoretical Framework for Understanding Regional Rural Development. In: Van der Ploeg, J.D. & Marsden, T. (eds). *Unfolding Webs: The Dynamics of Regional Rural Development*. Assen: Van Gorcum. pp. 1.

Vaughn, A. (2018). *UK's smart meter revolution at risk of being short-circuited*. [online] The Guardian. Available at: https://www.theguardian.com/business/2018/sep/15/smart-meter-revolution-at-risk-short-circuited [Accessed 19 Oct. 2018].

Venkatesh, V., Thong, J. and Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS Quarterly.* Volume 36(1). pp. 157-178.

Venkatesh, V., Thong, J. and Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS Quarterly.* Volume 36(1). pp. 160.

Verbong, G. and Loorbach, D. (2012). *Governing the energy transition: reality, illusion or necessity?*. New York: Routledge.

Verbong, G., Beemsterboer, S. and Sengers, F. (2013). Smart grids or smart users? Involving users in developing a low carbon electricity economy. *Energy Policy.* Volume 52. pp. 124.

Wang, J., Biviji, M. and Wang, W. (2011). Lessons learned from smart grid enabled pricing programs. In: *Proc. IEEE Power and Energy Conference*. Champaign: IEEE. pp. 420.

Western Power Distribution. (2018). *Projects: Smart Energy Isles*. [online]. Available at: https://www.westernpower.co.uk/projects/smart-energy-isles [Accessed 16th Nov. 2018].

Wieviorka, M. (1992). Case Studies: History or Sociology? In: Ragin, C. and Becker, H. eds. *What is a Case? Exploring the Foundations of Social Inquiry*. Cambridge: Cambridge University Press. pp. 159-172.

Wolsink, M. (2012). The research agenda on social acceptance of distributed generation in smart grids: Renewable as common pool resources. *Renewable and Sustainable Energy Reviews*. Volume 16. pp. 822-835.

Wolsink, M. (2012). The research agenda on social acceptance of distributed generation in smart grids: Renewable as common pool resources. *Renewable and Sustainable Energy Reviews*. Volume 16. pp. 831.

Wolsink, M. (2012). The research agenda on social acceptance of distributed generation in smart grids: Renewable as common pool resources. *Renewable and Sustainable Energy Reviews*. Volume 16. pp. 828.

Wüstenhagen, R., Wolsink, M. and Bürer, M. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy.* Volume 35. pp. 2683-2691.

Xenias, D., Axon, C., Whitmarsh, L., Connor, P., Balta-Ozkan, N. and Spence, A. (2015). UK smart grid development: An expert assessment of the benefits, pitfalls and functions. *Renewable Energy.* Volume 81. pp. 89-102.

Yin, R. (2013). *Case Study Research: Design and Methods.* California: Sage publications.

Yousafzai, S., Foxall, G. and Pallister, J. (2007). Technology acceptance: a meta-analysis of the TAM: Part 1. *Journal of Modelling in Management.* Volume 2(3). pp. 252.

Appendices

Appendix 1 - Online questionnaire

Smart-grid technology as a socio-technical system: residents' attitudes on the Isles of Scilly

This survey is for residents on the Isles of Scilly who are the bill payer(s) of their household. Participants must be over 16 years old. More than one bill payer can take the survey per household. Residents from all inhabited islands are encouraged to partake in the survey. All data collected is completely anonymised (even to the researcher) and will be statistically analysed. Participation in this survey is completely voluntary and participants may withdraw from the research at any time. This research is based on a dissertation thesis revolving around the social barriers to the adoption of Smart-Grid Technology. The research is completely neutral and only aims to highlight the 'human' dimension of socio-technical systems and assess the potential success of Hitachi's Smart Island project on the Isles of Scilly. The unique demography, environment and socio-economic composition of the Isles of Scilly make it a fantastic case study for this research. Thank you to all participants who partake in the survey.

* Required

What is your age? * 1

- 16-24
- 25-39
- 40-54
- 55-69
- 70 or Over

Which island are you resident on? * 2

- St Mary's
- St Martin's
- Tresco
- St Agnes
- Bryher

Approximately what is your annual income before tax? * 3

- Under £21,000
- £21,000 - £40,000
- £41,000 - £60,000
- £61,000 - £80,000
- Over £80 000

How many permanent residents live in your household? * 4

- 0-2
- 3-5
- 6-8
- 8-10
- More than 10

How well do you understand the term 'smart-grid'? * 5

- Very poorly
- Poorly
- Okay
- Well
- Very Well

How well do you understand the term 'internet of things'? * 6

- Very Poorly
- Poorly
- Okay
- Well
- Very Well

Is a smart meter installed within your household? * 7

- No
- Unsure
- Yes

To what extent do you agree with this statement 'I have a good understanding about the implementation of smart-grid technology on the Isles of Scilly' * 8

- Strongly Disagree
- Disagree
- Neither Agree or Disagree
- Agree
- Strongly Agree

9

How many times have you attended a panel, meeting, or forum and/or been in contact with any representative about the Smart Islands project on the Isles of Scilly? (this also includes emails or telephone calls) *

- 0-2 times
- 3-5 times
- 6-8 times
- 9-11 times
- Over 11 times

10

Do you feel the Smart Island's partnership has offered you the appropriate information about smart-grid technology and/or answered questions effectively (i.e. have they been informative and easy to communicate with) ? *

- Definitely No
- No
- Maybe/ Unsure
- Yes
- Definitely Yes

11

Would you remain with the same energy provider (due to ease of access, reliability, loyalty etc...) if a cheaper alternative was available? *

- Definitely No
- No
- Maybe/ Unsure
- Yes
- Definitely Yes

12

If you haven't already would you install a smart-grid component, for example a smart meter or relevant tablet display, in your household if available? (If already installed leave unanswered)

- Definitely No
- No
- Maybe/ Unsure
- Yes
- Definitely Yes

13

To what extent do you agree with this statement 'I am satisfied with the functionality of my smart meter/ smart-grid component'? (If no component installed leave unanswered)

- Strongly Disagree
- Disagree
- Neither Agree or Disagree
- Agree
- Strongly Agree

14

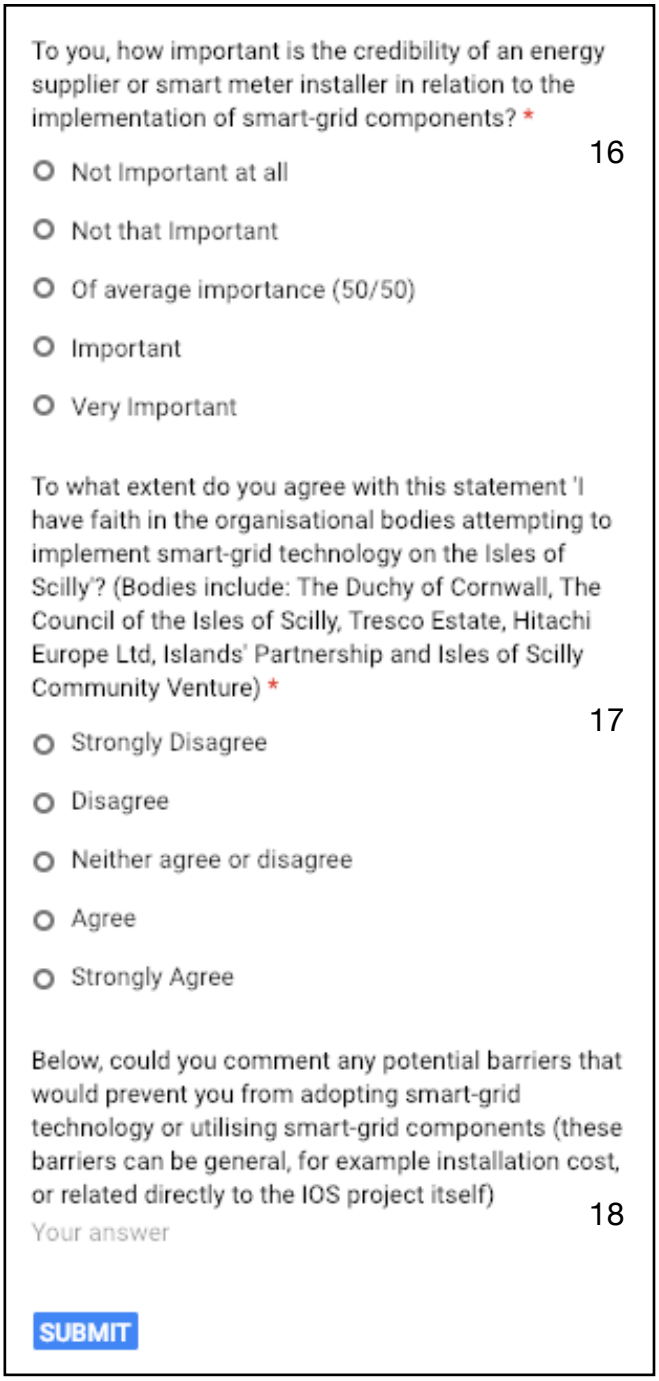
What would be/ what was the main reason you installed a smart meter or smart-grid component? *

- To reduce energy costs
- To reduce Island's emissions / increase energy efficiency
- To increase energy reliability by switching provider
- Ease of use (i.e. user interface on smart screen)
- To increase my control of household usage
- Recommended it by a friend or council member
- Other:

15

What would be/ what was the main reason you didn't install a smart meter or smart-grid component? *

- Confusing technology
- Satisfied with current provider or energy setup
- Unclear about ownership, compliance rules or privacy regulations
- A general lack of information provided by the installer
- The cost of the installation process
- Im not sure/ Unknown
- Other: _____



To you, how important is the credibility of an energy supplier or smart meter installer in relation to the implementation of smart-grid components? *

16

- Not Important at all
- Not that Important
- Of average importance (50/50)
- Important
- Very Important

To what extent do you agree with this statement 'I have faith in the organisational bodies attempting to implement smart-grid technology on the Isles of Scilly'? (Bodies include: The Duchy of Cornwall, The Council of the Isles of Scilly, Tresco Estate, Hitachi Europe Ltd, Islands' Partnership and Isles of Scilly Community Venture) *

17

- Strongly Disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly Agree

Below, could you comment any potential barriers that would prevent you from adopting smart-grid technology or utilising smart-grid components (these barriers can be general, for example installation cost, or related directly to the IOS project itself)

18

Your answer

SUBMIT

Notes:

- If online questionnaire screenshots are hard to interpret, due to pdf format issues, frequently discussed questions in the dissertation are as follows:
    - *Q14= What would be/ what was the main reason you installed a smart meter or smart-grid component?*
    - *Q15= What would be/ what was the main reason you didn't install a smart meter or smart-grid component?*

Appendix 2 - Participant consent form for interview

(Hitachi Representative) Interview

Participant Consent Form

I hereby consent to being interviewed by Rory Clark ('the researcher') as part of the student's dissertation research. The research aims to investigate potential cultural, socio-economic and demographic barriers to the adoption of smart-grid technology on the Isles of Scilly (IOS). Additionally, this dissertation research aims to gain an understanding of residents' views and knowledge levels in relation to the implementation of smart-grid technology on the IOS and whether this differs spatially. I give my consent in accordance with the following:

1. My participation within the interview is completely voluntary, and I don't expect to receive any benefit or payment for my participation.
2. I have the right to not answer any question(s), and have the right to withdraw from the interview at any point for any reason.
3. I understand that the interview will be recorded (audio only) for transcription purposes.
4. I have the right to request anonymity, and understand a pseudonym will be used instead of my name.
5. I have the right to request the removal of my answer(s) from the recorded audio.
6. I may request a full transcription of the interview, free of charge.
7. I understand that excerpts of the interview at any length may be used within research reports and will be presented to relevant Cardiff University employees.

Please check boxes below as appropriate:

I wish to review the full transcript before any data is used to check for factual errors ☐

I wish my name to be anonymised, and a pseudonym used instead ☐

Participant

Signed…….. Full name……..…….Date……..

Researcher

Signed…….. Full name……**Rory Clark**……..Date…….. **07.11.2018**……..

Appendix 3 - Cross tabulation of Q1 and Q15 responses

What is your age? * Main reason for not installing SG component Crosstabulation

			Main reason for not installing SG component							
			Confusing technology	Satisfied with current service	Unclear about ownership, compliance...	General lack of information	Cost of installation process	Not sure/ unknown	Other	Total
What is your age?	Under age 40	Count	0	6	3	2	2	5	2	20
		Expected Count	3.5	2.5	3.5	3.3	1.7	3.1	2.3	20.0
	40-54	Count	1	3	6	10	5	7	6	38
		Expected Count	6.6	4.8	6.6	6.3	3.3	5.9	4.4	38.0
	55-69	Count	4	4	9	3	0	4	3	27
		Expected Count	4.7	3.4	4.7	4.5	2.4	4.2	3.1	27.0
	70 and over	Count	13	0	0	2	2	0	1	18
		Expected Count	3.1	2.3	3.1	3.0	1.6	2.8	2.1	18.0
Total		Count	18	13	18	17	9	16	12	103
		Expected Count	18.0	13.0	18.0	17.0	9.0	16.0	12.0	103.0

Appendix 4 - Hypotheses table for Kruskal-Wallis test 2.1

Hypothesis number/ Test number	Null and alternative hypotheses
2.1 (Experience)	***H0**: There are no statistically significant differences between experience groups on dependant variables* ***H1**: There are statistically significant differences between experience groups on dependant variables*

Appendix 5 - Hypotheses table for series of Mann-Whitney U tests 2.2, 2.3, 2.4 and 2.5

Hypothesis number/ Test number	Null and alternative hypotheses
2.2.1 (Experience)	***H0****: There is not a statistically significant difference between experience groups '6 and over' and '3-5' and their understanding of the term 'smart-grid'* ***H1****: There is a statistically significant difference between experience groups '6 and over' and '3-5' and their understanding of the term 'smart-grid'*
2.2.2 (Experience)	***H0****: There is not a statistically significant difference between experience groups '6 and over' and '0-2' and their understanding of the term 'smart-grid'* ***H1****: There is a statistically significant difference between experience groups '6 and over' and '0-2' and their understanding of the term 'smart-grid'*
2.3.1(Experience)	***H0****: There is not a statistically significant difference between experience groups '6 and over' and '3-5' and their understanding of the term 'Internet of Things'* ***H1****: There is a statistically significant difference between experience groups '6 and over' and '3-5' and their understanding of the term 'Internet of Things'*
2.3.2 (Experience)	***H0****: There is not a statistically significant difference between experience groups '6 and over' and '0-2' and their understanding of the term 'Internet of Things'* ***H1****: There is a statistically significant difference between experience groups '6 and over' and '0-2' and their understanding of the term 'Internet of Things'*
2.4.1 (Experience)	***H0****: There is not a statistically significant difference between experience groups '6 and over' and '3-5' and the extent to which they agree with this statement 'I have a good understanding about the implementation of smart-grid technology on the Isles of Scilly'* ***H1****: There is a statistically significant difference between experience groups '6 and over' and '3-5' and the extent to which they agree with this statement 'I have a good understanding about the implementation of smart-grid technology on the Isles of Scilly'*
2.4.2 (Experience)	***H0****: There is not a statistically significant difference between experience groups '6 and over' and '0-2' and the extent to which they agree with this statement 'I have a good understanding about the implementation of smart-grid technology on the Isles of Scilly'* ***H1****: There is a statistically significant difference between experience groups '6 and over' and '0-2' and the extent to which they agree with this statement 'I have a good understanding about the implementation of smart-grid technology on the Isles of Scilly'*
2.5.1 (Experience)	***H0****: There is not a statistically significant difference between experience groups '6 and over' and '3-5' and whether they feel they have been given appropriate information* ***H1****: There is not a statistically significant difference between experience groups '6 and over' and '3-5' and whether they feel they have been given appropriate information*
2.5.2 (Experience)	***H0****: There is not a statistically significant difference between experience groups '6 and over' and '0-2' and whether they feel they have been given appropriate information* ***H1****: There is not a statistically significant difference between experience groups '6 and over' and '0-2' and whether they feel they have been given appropriate information*

Appendix 6 - Cross tabulation for Q2 and Q14 responses

Which island are you resident on? * Main reason for installing SG component Crosstabulation

			Main reason for installing SG component					
			Reduce energy cost	Reduce Island's emissions	To increase control of household usage	Reccommended by friend/ council member	Other	Total
Which island are you resident on?	St Mary's	Count	46	9	24	5	2	86
		Expected Count	40.1	19.2	20.9	4.2	1.7	86.0
		% within Which island are you resident on?	53.5%	10.5%	27.9%	5.8%	2.3%	100.0%
		% within Main reason for installing SG component	95.8%	39.1%	96.0%	100.0%	100.0%	83.5%
		% of Total	44.7%	8.7%	23.3%	4.9%	1.9%	83.5%
	Off island	Count	2	14	1	0	0	17
		Expected Count	7.9	3.8	4.1	.8	.3	17.0
		% within Which island are you resident on?	11.8%	82.4%	5.9%	0.0%	0.0%	100.0%
		% within Main reason for installing SG component	4.2%	60.9%	4.0%	0.0%	0.0%	16.5%
		% of Total	1.9%	13.6%	1.0%	0.0%	0.0%	16.5%
Total		Count	48	23	25	5	2	103
		Expected Count	48.0	23.0	25.0	5.0	2.0	103.0
		% within Which island are you resident on?	46.6%	22.3%	24.3%	4.9%	1.9%	100.0%
		% within Main reason for installing SG component	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	46.6%	22.3%	24.3%	4.9%	1.9%	100.0%

Appendix 7 - Cross tabulation for Q2 and RFI (reason for installing) 'to reduce energy costs' responses

Which island are you resident on? * (RFI) Reduce energy costs Crosstabulation

			(RFI) Reduce energy costs		
			No	Yes	Total
Which island are you resident on?	St Mary's	Count	40	46	86
		Expected Count	45.9	40.1	86.0
		% within Which island are you resident on?	46.5%	53.5%	100.0%
		% within (RFI) Reduce energy costs	72.7%	95.8%	83.5%
		% of Total	38.8%	44.7%	83.5%
	Off island	Count	15	2	17
		Expected Count	9.1	7.9	17.0
		% within Which island are you resident on?	88.2%	11.8%	100.0%
		% within (RFI) Reduce energy costs	27.3%	4.2%	16.5%
		% of Total	14.6%	1.9%	16.5%
Total		Count	55	48	103
		Expected Count	55.0	48.0	103.0
		% within Which island are you resident on?	53.4%	46.6%	100.0%
		% within (RFI) Reduce energy costs	100.0%	100.0%	100.0%
		% of Total	53.4%	46.6%	100.0%

Appendix 8 - Cross tabulation for Q2 and RFI (reason for installing) 'to reduce island's emissions' responses

Which island are you resident on? * (RFI) Reduce Island's emissions Crosstabulation

			(RFI) Reduce Island's emissions		
			No	Yes	Total
Which island are you resident on?	St Mary's	Count	77	9	86
		Expected Count	66.8	19.2	86.0
		% within Which island are you resident on?	89.5%	10.5%	100.0%
		% within (RFI) Reduce Island's emissions	96.3%	39.1%	83.5%
		% of Total	74.8%	8.7%	83.5%
	Off island	Count	3	14	17
		Expected Count	13.2	3.8	17.0
		% within Which island are you resident on?	17.6%	82.4%	100.0%
		% within (RFI) Reduce Island's emissions	3.8%	60.9%	16.5%
		% of Total	2.9%	13.6%	16.5%
Total		Count	80	23	103
		Expected Count	80.0	23.0	103.0
		% within Which island are you resident on?	77.7%	22.3%	100.0%
		% within (RFI) Reduce Island's emissions	100.0%	100.0%	100.0%
		% of Total	77.7%	22.3%	100.0%

Appendix 9 - Signed ethical approval form

CARDIFF UNIVERSITY SCHOOL OF GEOGRAPHY AND PLANNING

Ethical Approval Form

Student Projects (Undergraduate & Taught Masters)

In the case of dissertations, it is the responsibility of the student to submit this form, duly signed by their supervisor, and secure ethical approval prior to any fieldwork commencing. Please submit an electronic copy to your supervisor prior to commencing fieldwork. Your supervisor will then forward the completed form to gandpenquiries@cardiff.ac.uk. You should also include a copy of the completed form as an appendix to your submitted dissertation.

Title of Project:Social barriers preventing the potential success of smart-grid technology on the Isles of Scilly *(Subject to change)*

Name of Student(s): Rory Francis Clark

Name of Supervisor/Module Leader: Prof. Richard Cowell

Degree Programme and Level: Geography (Human) - 3rd Year

Date:25. 10. 2018

Recruitment Procedures:

		Yes	No	N/A
1	Does your project include children under 16 years of age?		**x**	
2	Does your project include people with learning or communication difficulties?			**x**

3	Does your project include people in custody?		**x**	
4	Is your project likely to include people involved in illegal activities?		**x**	
5	Does project involve people belonging to a vulnerable group, other than those listed above?		**x**	
6	Does your project include people who are, or are likely to become your clients or clients of the department in which you work?		**x**	
7	Does your project include people for whom English / Welsh is not their first language?		**x**	

Consent Procedures:

		Yes	**No**	**N/A**
8	Will you tell participants that their participation is voluntary?	**x**		
9	Will you obtain written consent for participation?	**x**		
10	If the research is observational, will you ask participants for their consent to being observed?	**x**		
11	Will you tell participants that they may withdraw from the research at any time and for any reasons?	**x**		
12	Will you give potential participants a significant period of time to consider participation?	**x**		

Possible Harm to Participants:

		Yes	No	N/A
13	Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?		**x**	
14	Is there any realistic risk of any participants experiencing a detriment to their interests as a result of participation?		**x**	

If there are any risks to the participants you must explain in the box on page 4 how you intend to minimise these risks

Data Protection:

		Yes	No	N/A
15	Will any non-anonymised and/or personalised data be generated and/or stored?		**x**	
16	Will you have access to documents containing sensitive data about living individuals?		**x**	
	If "Yes" will you gain the consent of the individuals concerned?			

If there are any other potential ethical issues that you think the Committee should consider please explain them in the box on page 4. It is your obligation to bring to the attention of the Committee any ethical issues not covered on this form.

Supervisor's declaration

As the supervisor for this student project, I confirm that I believe that all research ethical issues have been dealt with in accordance with University policy and the research ethics guidelines of the relevant professional organisation.

Date: 26th October 2018 **Name:** R. Cowell **Signature:** 

If any of the shaded boxes have been ticked the supervisor/module leader must explain in the box on page 4 of this form how the potential ethical issue will be handled

Please explain how the identified potential research ethics issue/s will be handled